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OUTLINES

OF THE

GEOLOGY OF JAPAN:

DESCRIPTIVE TEXT

TO ACCOMPANY THE

GEOLOGICAL MAP OF THE EMPIRE
ON THE SCALE 1: 1,000,000.

COMPILED BY THE OFFICIALS OF THE

IMPERIAL GEOLOGICAL SURVEY OF JAPAN,

DEPARTMENT OF AGRICULTURE AND COMMERCE.

TOKYO:

Published by the Geological Survey.

1902.

5550
5350
792589

ERRATA.

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„	70,	„	2	„	above,	„	" Nanaino "	„	" Nanaimo "
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„	71,	„	10	„	„	„	" dubovalis "	„	" subovalis "
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„	130,	„	17	„	above,	„	" Teshiro "	„	" Teshio "
„	131,	„	4	„	below,	„	" 936,243 "	„	" 10,730 "
„	137,	„	17	„	„	„	" N.W."	„	" N.E."
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„	„	„	12	„	„	„	" south "	„	" east "
„	198,	„	12	„	„	„	" Chikugo "	„	" Chikuzen "
„	216,	„	2	„	„	„	" 27 "	„	" 24 "

Glossary, insert " Ri............Measure of length. 1 *ri* = 3927.27 meters.

CONTENTS.

PART I.

TOPOGRAPHY.

CHAPTER I.—Situation, area, coast line 1
CHAPTER II.—Orography 3

PART II.

GEOLOGY.

CHAPTER III.—General Remarks 17
CHAPTER IV.—Archæan Group 20
  I. Gneiss System 21
  II. Crystalline Schists System 26
CHAPTER V.—Palæozoic Group 33
  I. Stratigraphy and Lithology... 34
  II. Local Descriptions 42
CHAPTER VI.—Mesozoic Group 48
  I. Triassic System 49
  II. Jurassic System 52
  III. Cretaceous system... 59
CHAPTER VII.—Cainozoic Group 75
  I. Tertiary System 76
  II. Quaternary System 107
CHAPTER VIII.—Igneous Rocks 115
  I. Older Igneous Rocks 115
  II. Younger Igneous Rocks 117

PART III.

ECONOMIC GEOLOGY.

CHAPTER IX.—Metalliferous Deposits 123
  I. Gold Mines... 124
    Hashidate 124

Hō ... 124
Kanahira ... 125
Hoshino ... 125
Serigano ... 125
Yamagano ... 127
Kago ... 128
Kinkwaseki ... 128
Zuihō ... 129
II. Placer Gold ... 130
III. Gold and Silver Mines ... 131
Ponshikaribets ... 131
Matsuoka ... 131
Handa ... 132
Takatama ... 133
Aikawa ... 133
Kuratani ... 135
Kōsen ... 136
IV. Gold, Silver and Copper Mines ... 136
Ikuno ... 136
Ōmori ... 138
V. Gold and Copper Mine ... 139
Ōkuzu ... 139
VI. Silver Mines ... 140
Mizusawa ... 140
Tsubaki ... 140
Hachimori ... 141
Shirayama ... 141
Tagonai ... 142
Hata ... 142
Innai ... 143
Kuromori ... 144
Karuisawa ... 144
Akenobe ... 145
VII. Silver and Copper Mines ... 146
Towada ... 146
Kosaka ... 146
Ōmaki ... 147
Hisanichi ... 148
Hatasa ... 148
Waidani ... 149

Yoshioka 149
Sasagatani 150
VIII. Silver and Lead Mines 151
Hosokura 151
Kamioka 152
IX Silver, Copper and Lead Mines... 153
Daira 153
Mozumi 153
X. Copper Mines 154
A. *Vein Deposits* 154
Ani... 154
Arakawa... 156
Furokura 157
Osaruzawa 157
Mizusawa 159
Nagamatsu 159
Kusakura 160
Maze 160
Ashio 161
Ogoya 162
Ate... 163
Omodani 164
Tsuboi 165
Yamate 165
Kōei 166
Kokusei... 167
Obie 167
Adakai 168
Udo 169
Dōgamaru 169
Zōmeki 170
Hōgashō... 170
B. *Bedded Deposits*... 171
Kune 171
Tateri 172
Kawadayama... 172
Hisamune 172
Higashiyama... 173
Besshi 173
Nishinokawa... 175

Kurotaki ... 175
Hokoishi ... 176
Terano ... 176
Ōse... 176
Hibira ... 177
Makimine ... 177
Sawatari... 178
Itsuki ... 178
Fukada ... 179
XI. Iron Mines ... 180
Kamaishi ... 180
Sennin ... 181
Kuriki and Omakigura... 181
Akadani... 181
Nakakosaka. ... 182
XII. Iron Sand ... 182
XIII. Tin Mines ... 183
Kiura ... 183
Taniyama ... 183
XIV. Stream Tin ... 184
XV. Antimony Mines ... 185
Kano ... 185
Ichinokawa ... 185
XVI. Manganese Mines... 186
Ribets ... 186
Fukaura... 187
CHAPTER X.—Non-metallic Mineral Products... 187
I. Graphite... 187
II. Coal ... 188
A. *Anthracitic Coal* ... 190
Coal-field of Moriyoshi, Ugo ... 190
Coal-field of Higashi-Muro-gōri, Kii... 190
Mesozoic Coal-field of Nagato ... 191
Amakusa Coal-fields ... 191
B. *Bituminous Coal* ... 192
HOKKAIDŌ ... 192
Sōya Coal-fields ... 193
Teshio Coal-fields... 193
Ishikari Coal-fields ... 193
Kushiro Coal-fields ... 194

Kayanuma Coal-field 195

HONSHŪ... 195

Aburato Coal-field... 195

Iwaki-Hitachi Coal-field 196

Tertiary Coal-field of Asa-gōri, Nagato 197

KYŪSHŪ... 198

Chikuhō Coal-field 198

Coal-fields of Northern Hizen 204

Matsu-shima Coal-field... 205

Coal-fields of Takashima and adjacent Islands... 205

Miike Coal-field 205

SOUTHERN ISLANDS 206

Coal-field of the Yaeyama Islands 206

Coal-fields of Taiwan (Formosa) 206

C. *Lignitic Coal* 207

D. *Peat* 208

III. Petroleum 208

HOKKAIDŌ 209

Penkeopirarika, Yuputs-gōri, Iburi 209

Shumbets, Atsuta-gōri, Ishikari 210

UGO 211

Nigorikawa, Minami-Akita-gōri 211

Izumi, Minami-Akita-gōri 211

Kami-Oguni, Yuri-gōri... 211

ECHIGO 212

Kurokawa, Kita-Kambara-gōri 212

Niitsu, Naka-Kambara-gōri... 213

Higashiyama, Koshi-gōri 214

Takezawa, Koshi-gōri 216

Amaze, Santō-gōri 216

Kusōzu and Ushirodani, Santō-gōri 217

Myōhōji, Kariha-gōri 218

Nishiyama Oil-field, Kariha-gōri 219

Oil-fields of Higashi-Kubiki-gōri 222

Oil-fields of Naka-Kubiki-gōri 223

Oil-field of Nishi-Kubiki-gōri 225

SHINANO 225

Oil-field of Tomikura, Shimo-Minochi-gōri ... 225

Oil-field of Saijō, Kami-Minochi-gōri 226

TŌTŌMI 226

Oil-field of Sugegaya, Haibara-gōri 226
TAIWAN... 226
IV. Asphalt 227
V. Amber 227
VI. Stones for Buildings and Monuments 227
VII. Clays and Natural Cement... 232
VIII. Precious Stones 234
IX. Abrasive Materials 236
X. Material for Inkstones, or "Suzuri-ishi"... 237
XI. Slates 238
XII. Steatite, Agalmatolite, Asbestos and Gypsum 239
XIII. Limestone 240
XIV. Fluorspar, Talc, Mica and Quartz 242
XV. Porcelain Glaze, Mineral Pigments and Medicinal Minerals... 243
XVI. Sulphur 245
XVII. Phosphates 246
XVIII. Mineral Springs 247

PART I.

TOPOGRAPHY.

CHAPTER I.

SITUATION, AREA, COAST LINE.

The Empire of Japan, consisting of a large number of islands situated off the eastern coast of the Asiatic continent, stretches from 119° 20′ E. long. (Kwasho in the Hōko or Pescadores Group) to 156° 32′ E. (Shumshu Island in the Kuriles) and from 21° 45′ N. lat. (Vele Rete Rocks of Formosa) to 50° 56′ N. (Alaid Island in the Kuriles). The long chain of islands extending over 4,700 kilometers continues in graceful curves forming three distinct arcs, viz.: Ryūkyū, Japan Proper, and Chishima. The three arcs, in combination with the peninsulas of Korea and Kamtchatka and the Island of Saghalien, enclose successively the Eastern Sea, Sea of Japan, and Okhotsk Sea.

The number of islands above 4 km. in circumference exceeds 500; their total area is 417,389.68 sq. km., and their total length of coast line is 29,191.07 km. The ratio of the total length of coast line to the geometrical circumference[1] is 12.805 : 1.

---

[1] By the geometrical circumference is meant the circumference of a circle of equal area.

The areas and lengths of coast line of the five largest islands are as follows:—

	Area in sq. kilometers.	Length of coast line in kilometers.	Ratio of length of coast line to geometrical circumference.
Honshū	223,520.60	7,669.55	4.576: 1
Hokkaidō (main island)	77,913.25	2,290.91	2.314: 1
Kyūshū	35,656.97	3,382.11	5.053: 1
Taiwan	34,752.85	1,177.09	1.781: 1
Shikoku	17,756.15	1,771.88	3.838: 1

The coast line of Taiwan or Formosa is, on the whole, poor in indentation; there are some small bays in the north-eastern side, the harbours of Kiirun (Keelung) and Suō being among them.

Hokkaidō has only a few bays, the most noteworthy being Volcano Bay and Hakodate Bay on the south and the Bays of Nemuro and Akkeshi on the east.

Kyūshū ranks first in coast development and possesses many good harbours. On the south we have the large Bay of Kagoshima and the Ariake-no-umi. The western coast of Kyūshū is the most indented in the whole empire; the prominent features of it are the Sea of Yatsushiro which is full of small islands, the deep Ariake-no-umi, and the entire coast of the province of Hizen which comprises many peninsulas and adjacent to which lie numerous islets. The Bays of Imari, Karatsu, and Hakata, and the Kuki-no-umi are on the northern coast, and the Beppu Bay is on the north-east. Southward from Beppu Bay to the harbour of Hososhima the coast is of Rias type. Still more southward the eastern coast of Hyūga is singularly linear.

Shikoku is devoid of large inlets. The eastern and western sides opposite Kii and Kyūshū are serrated.

The long coast line of Honshū or the Main Island varies in its characteristic features in different parts. On the southern face of the Pacific side many large arms of the sea run in northward, forming the peninsulas of Kii, Chita, Atsumi, Izu, Miura, and Awa-Kazusa; on the eastern face the only bay is that of Ishinomaki. Some parts of the coasts of Kii, Rikuzen and Rikuchū approach the Rias type. The coast of the Sea of Japan is monotonous, with a few inlets and projections of which Naka-umi and Miho Bay in Izumo, and the Bays of Wakasa and Tsuruga, the Bay of Toyama with the Peninsula of Noto, and the Hachirō-gata with the small peninsula of Ogashima, may be mentioned. The Setouchi or Inland Sea of Japan, famous for its labyrinth of islets and peninsulas, presents a characteristic type of coast scenery.

CHAPTER II.

OROGRAPHY.

The Islands of the Japanese Empire are but the summit of a half-submerged great mountain system that girdles the Pacific side of the Asiatic continent. Consequently the country is essentially a mountainous tract. The widest plains are the high Diluvial flats in Northern Japan and Hokkaidō. As none of the islands has its centre more than a hundred kilometers distant from the sea, there is no room for the development of great river systems.

To begin from the southern-most of the islands: Taiwan or Formosa presents a comparatively simple topography. A great water-shed range beginning at the south end, Nankō, follows the longer axis of the island and passes N. N. E., and eastwards of the middle line, forming a continuous mountain-chain that rises above 3,000 meters in height through Setsu-zan (Mt. Silvia); thence turning E. N. E. it reaches the sea near Suō. The bold escarpments seen on the coast south of Suō are the end of the range cut transversely to its course. The Taiwan Mountain Range far exceeds the highest ranges in other parts of Japan in height; of Niitaka-yama (Mt. Morrison), the highest peak of which is said to reach over 4,000 meters in height and to lie a little westward of the main ridge, accurate measurements are as yet lacking.

On the west of the back-bone range, a broad belt of hills, the so-called Bankairei, runs parallel to it. In the north, many transverse valleys cut both the hilly tract and the high mountain region, and extend westwards, but in the south the plain of the Katansui-kei intervenes between the high and low ranges. Further westward, bordering on the sea, a large plain extends north and south. On the upper course of the River Tansui lies the small but important plain of Taihoku which is bounded on the north by the small volcanic group of Taiton-zan.

Eastward the axial mountains slope steeply in part to the sea and in part to a long, narrow depression formed by three rivers, the Mokka-kei, Shūkoran-kei, and Pinan-kei; to the east of this tectonic valley which is known as the longitudinal valley of Taitō rises a narrow range of low mountains known by the name of the Taitō Coast Range.

Some of the islands of Ryūkyū and adjoining islands, in spite of their small area, possess comparatively high mountains; Yae-dake (1885 m.) on Yaku-shima outrivals the highest mountains in the islands of Kyūshū. Omoto-dake on Ishigaki-jima, Nishimei-dake on Okinawa-jima, and Yuwan-dake on Amami-Ōshima are higher than 500 meters.

The jaggedness of the coast line of Kyūshū reveals the complexity of its structure. Geotectonically, the island of Kyūshū may be roughly divided into two parts by a line passing through the Strait of Hayasaki (between the Islands of Amakusa and Shimabara Peninsula) and thence to the head of Beppu Bay. Southward of this line runs the Kyūshū Mountain Range, while north of it are the Aso Volcano and lesser volcanic groups in Buzen, Bungo, and Hizen, and the Tsukushi Range.

The Kyūshū Mountain Range begins in the west at the Koshiki Islands. Extending N.E. it reaches to Jōgū-dake (1049 m.) in Satsuma and thence to the most mountainous portions of Kyūshū (which contains within it the plains of Hitoyoshi), forming the peaks of Shiraga-dake (1497 m.), Ishido-yama (1745 m.), and Ichibusa-yama (1820 m.) in the south, and Naidaijin-yama (1674 m.), Sambō-yama (1645 m.), and Morozuka-yama (1513 m.) in the north, and finally sinks under the Bungo Strait. The nearly meridional linear coast line of southern Hyūga is the effect of the strike of the young Tertiary strata developed along the coast; the ground structure of the older formation in general, however, shows conformity to the general northeasterly trend of the Kyūshū Range. Beginning at the volcanic plain of Miyakonojō in western Hyūga, a wide tract of volcanic origin extends westward and southward over the greater part of Satsuma and Ōsumi. There the thick mass of ejectamenta fills up the depressions of the ancient low hills and the country presents a somewhat levelled appearance with numerous volcanic cones and some few mountains of the old formations.

The line of active volcanoes commencing in the southern islands is continued by the beautiful cones of Kaimon and of Sakura-jima in Kyūshū and passes thence to the large volcanic group of Kirishima culminating in Karakuni-dake (1762 m.) and Takachiho-no-mine (1659 m.). The plains of Hitoyoshi and of Izumi seem to lie on a formerly continuous longitudinal depression which has been subsequently cut by the formation of the volcanic group of Yahazu and Asahi.

The rivers run mostly transverse to the mountains. The Kuma-gawa below Hitoyoshi, and its tributary the Kawabe-gawa, and the large rivers of Hyūga such as the Ichinose-gawa, Mimitsu-gawa, and Gokase-gawa are all transverse valleys.

In the northern half of Kyūshū, the most conspicuous group of mountains is formed by a large number of volcanoes covering the wide area containing the greater part of Bungo, the southern half of Buzen, and the western half of Higo. The outermost crater of Aso, the largest in Japan, measures 24km. by 16 km.; it has five cones within it, the highest of them being Taka-dake 5120 ft. (1690 m.). North of Aso lies the volcano of Kujū-san (1860 m.) with a central cone 1717 m. high. North-east of it the two volcanoes of Tsurumi-dake (1480 m.) and Yufu-dake stand on the west shore of Beppu Bay. Futago-yama in the peninsula of Kunisaki to the north of Beppu Bay seems to be an old volcano. Kimbō-san, north-west of Kumamoto, is also of volcanic origin. Agglomeratic rocks play an important part in the formation of the volcanic region and erosion acting on these easily crumbling rocks gives mountains and valleys fantastic forms in many places, among which the most noted is the Yaba-kei in Bungo.

The Tsukushi Mountain Range stretching N.E.–S.W., in the north of the volcanic tract, consists of comparatively low older mountain masses together with flat table-lands of later sedimentary and volcanic origin. South-east of Fukuoka the range is cut into two by the transverse valley of the Mikasa-gawa. The eastern section consists of detached clusters of low mountains, with the intervening coal basins of Chikuzen and Buzen.

The western portion is formed mainly of granitic massifs, and culminates in Sefuri-yama and Ama-dake a little over 1,000 m. high. Westward, the northern part of Hizen is an eroded table-land formed of Tertiary rocks and basalt. In the formation of the southern peninsulas of Hizen volcanoes have played a most important part. Of these Unzen-dake (1483 m.) in Shimabara and Tara-dake (1223 m.) are most conspicuous. The islands of Hirado and Iki are nothing but detached portions of northern Hizen. The islands of Tsushima and the Gotō Group have structurally little in common with the the main island of Kyūshū; they appear to have been formed in a different way and at a different time.

In Shikoku we have the continuation of the Kyūshū Range. The Shikoku Mountain Range, with its axis in the north of the island, passes through its whole length in an east-north-easterly direction. The highest ridge runs between Ishizuchi-san and Tsurugi-san (2242 m.) and is cut by the transverse portion of the valley of the Yoshino-gawa forming the gorges of Ōboke and Koboke.

The main portion of the Yoshino-gawa together with the Shigenobu-gawa on the north, the Monobe-gawa and Niyodo-gawa on the south are examples of longitudinal valleys. The Hiji-kawa and Shimanto-gawa cut the western portion of the island transversely on opposite sides. In the north of the plain of the Yoshino-gawa the small Sanuki Range forms the boundary between Sanuki and Awa.

The region north of the Sanuki Range presents a marked contrast to the other parts of mountainous Shikoku. There, in the peninsulas of Sanuki and Takanawa, the hills are low and round, and the plains extend along the coast.

Awaji resembles northern Shikoku in its structure; through the south of it runs a regular mountain-range, while the northern part is occupied by irregular mountain masses.

Structurally, Honshū or the Main Island is divided into two parts, northern and southern, by a tectonic line traversing the middle of the island from the Pacific Ocean to the Sea of Japan, which is indicated by the course of the Fuji-kawa and of its tributary, the Kamanashi-gawa, and by the upper course of the Sai-gawa and the Hime-gawa.

Close to the east of the line and nearly parallel to it runs the line of volcanoes formed by Fuji, Yatsuga-take, Tateshina, and others. Geologically and topographically, there are wide differences between the country east of this line and that west of it; the former includes Northern Japan which is comparatively flat and open, with the alluvial plain of Kwantō, the most extensive in the Empire, and many prairie-like "haras" in the north.

Southern Japan may be subdivided as follows:—

1. The mountain-land of Chūgoku, which comprises the portion to the west of the meridian of 135° E. long.

2. The Plateau of Tamba and Peninsula of Kii, which lie more eastward and are bounded by the Bay of Tsuruga, Lake Biwa, and the Sea of Ise on the east.

3. The high mountainous region comprising the Plateau of Hida, the Kiso mountains and the Akaishi mountains.

Chūgoku has somewhat the character of a plateau; the low mountains, mostly about 500 meters high, running in diverse directions. The high peaks are mostly volcanoes, the most noticeable being Daisen (1877 m.), in the province of Hōki, and Sambe-yama (1227 m.) on the Izumo-Iwami frontier. A hilly region in the north of Izumo, clearly separated from the main mass of Chūgoku by the depression of the Nakami and Lake Shinji, is called the Shinji Range. Plains, with the exception of those of Harima and Okayama, are only small patches of level ground along the coast or at river-mouths.

The rivers of importance are the Higashi Ōkawa and Nishi Ōkawa of Buzen, Ashida-gawa of Bitchū, and Gō-gawa of Iwami; all flow transversely to the general strike of the mountains.

The Islands of Oki, in the Sea of Japan, are geologically parts of Chūgoku. The form of the western group consisting of three islands resembles that of Santorin in the Mediterranean.

The triangular Plateau of Tamba is definitely bounded on the south-east by the depression of Lake Biwa and Yodogawa valley. The eastern portion is highest and contains Hira-dake (1233 m.); Myōken-zan (908 m.) stands at the southernmost corner, and the two granitic massifs of Tango and Rokkō lie respectively on the north-west and south-west of the plateau.

The peninsular region east and south of the Tamba Plateau, bounded by the depression of Lake Biwa and Yodogawa on one side and the plain of Mino-Owari on the other, is divided into two portions, of different geological structure, by the line of longitudinal valleys of the Kino-kawa on the west and the Kushida-gawa on the east. The southern portion, containing the whole of the Province of Kii, is a region of high mountains, with no level ground of importance except the plain on the lower course of the Kino-kawa. The highest region lies to the east of the sinuous transverse valley of the Kumano-gawa; the high north and south range of Ōmine-san, culminating in Misen (1876 m.) intervenes between the Kumano-gawa and its tributary, the Kitayama-gawa. Further east Ōdaigahara-san (1685 m.) stands on the frontier of Ise.

On the west of the Kumano-gawa the elevations do not exceed 1200 meters, with the one exception of Obago-dake (1400 m.).

North of the Kino-kawa rises the narrow Izumi Range stretching east and west along the boundary of Kii and Izumi. This is a continuation of the Sanuki Range in Shikoku, and culminates in Katsuragi-san (858 m.). Nearly at right angles with the Izumi Range the Kongō Range (Kongō-san 1237 m.) runs north and south between the plains of Osaka and Nara. The eastern side is rather precipitous, while the western side is flanked at the southern end by very low hills. The Yamato-gawa cuts it in the north and separates the Ikoma Group from the main range. To the east of the Kongō Range the two parallel ranges of Kasagi and Suzuka run also north and south, the towns of Nabari, Uyeno, and Minakuchi standing on the intervening low land. The former range is low, and nowhere exceeds 1000 m. The latter is a long, high range, exceeding 1000 m. at many points. It is cut in the middle by the Suzuka-gawa, Reisen-zan, Suzuga-take, Kamaga-take and other peaks being north of that river and Tsubone-take and Ōbora-san south of it. North-east of the Suzuka Range, and separated from it by the valley of the Inabe-gawa, lies the small Yōrō Range bordering on the Mino-Owari plain; its highest peak is Shōga-take (1037 m.).

The above mentioned parallel ranges of Kongō, Kasagi, Suzuka, and Yōrō, running north and south, are *horst* mountains, and the depressed portions form the neighbouring plains of Osaka, Nara, and Mino-Owari.

Passing eastward, we find, in the eastern extremity of Southern Japan, the most mountainous portion of the island. It is barely linked on the west to the Plateau of Tamba and to the Suzuka Range by low ridges not over 400 meters in height; it is clearly defined on the east by the depression-line reaching from the mouth of the Fuji-kawa to the mouth of the Hime-gawa on the Sea of Japan, the highest point in which, the Shiojiri Pass, is 1060 m. high. Should we traverse the thick mountain mass straight across in a north-west direction from the mouth of the Fuji-kawa to the city of Kanazawa on the coast of the Sea of Japan, we should have first to climb the Akaishi Range, 3000 m. high; then descend to the valley of the Tenryū; next we should pass over the Kiso mountains, more than 2000 m. high, and down to the Kiso valley; then over Ontake, 3000 m, high, and lastly across the Plateau of Hida, attaining a mean height of 1000 meters, until we reached the Sea of Japan.

The Akaishi Range is separated from the Kiso Range by the Yahagi-gawa and the upper course of the Tenryū; the mountain axis passes from north-east to south-west in the southern portion and nearly north and south in the main or northern portion. The highest mountains are in the northern part, among which are Akaishi-yama (3093 m.), Senjōga-dake (2970 m.), Komaga-take (in Kōshū, 3001 m.), Hōōzan (2912 m.), and the many peaked Shirane-san (3150 m.). The western side of the Range separated from the main mass by the Tōyama-gawa, a branch of the Tenryū, and the Toyo-kawa in Mikawa, is designated as the Ina Range. Southward, the Akaishi Range terminates in the plains of Mikawa and Tōtōmi; on the north-west the long terraced plain of Iida separates it from the Kiso Range.

The Kiso Range, on the left side of the Kiso-gawa valley, extending in a north-north-easterly direction, has its highest points between Komaga-take in Shinano (2880 m.), and Ena-san (2240 m.); the height averages between 1500 and 2000 meters. It ends in the south-west in the low hilly tract facing the Mino-Owari plain.

The plateau region comprising the whole of Hida and covering the greater parts of Mino and Echizen is bordered on the east by the Hida Range. It towers between Hida and Etchū on the west and Shinano and Echigo on the east, and has been called the Snow Mountains by J. J. Rein from the great drifts of snow that are found even in late summer.

It attains a mean height of 2500 m., and is crowned by the three-peaked Yariga-take, Shirouma-dake, and other summits reaching 3000 m., and still further heightened and augmented by the volcanic masses belonging to the Norikura Volcanic Chain that passes alongside of this range the chief volcanoes of which are Ontake (3185 m.), Norikura (3166 m.), and Iwō. Close to the west of the ridge of Yariga-take runs the equally high ridge of Tate-yama, accompanied by volcanic off-shoots. The torrent known as the Kurobe-gawa flows between the two high ridges; its banks are so high and precipitous that it is said that along the whole course of the stream in the mountains it can be crossed at only one place.

The northern part of Hida is drained by the Takara-gawa and the Miya-gawa, tributaries of the Jintsū-gawa, and the southern part by the Masuda-gawa, tributary of Kiso-gawa. The two parts are separated by the Miya Pass, only 800 m. high, to the north of which lies the small basin of Takayama. In the north-west of the plateau region, to the west of the valley of the Imizu-gawa, there is another high ridge running north and south, culminating in the neighbourhood of Haku-san; northward it lowers to an undulating hilly tract which lies between the plains of Kaga and Etchū and continues to the Peninsula of Noto. The plateau region is lost southward in the Mino-Owari Plain and ends in the south-west at the Ibuki-Mikuni Range, on the western boundary of Mino, which is linked to the Suzuka Range.

The line of large volcanoes that marks the boundary between Northern and Southern Japan is known by the name of the Fuji Volcanic Zone. Commencing in the islands in the south of Izu, it passes through the peninsula of Izu to Hakone Volcano, and culminates in Fuji. The circular area, in which Fuji stands, so beautifully displaying the typical volcanic cone, contains the picturesque lakes at the foot of the mountain and is bounded by the curved ranges of Tenshu, Misaka and Tanzawa. Further beyond we observe another and a far grander encircling wall of mountains, formed on the west by the steep wall of the Akaishi Mountains and on the north and north-west by Komaga-take

Yatsuga-take, Kimpu-zan, Kokushi-dake and other mountains of Kwantō.

The Plain of Kōfu lies to the north of the Misaka Range. From the plain comparatively easy roads lead northward *via* Ueda and Nagano to Naoetsu on the Sea of Japan, and north-westward to the plain of the Hime-gawa, by way of Lake Suwa through the plains of Matsumoto and Ōmachi. Between the two roads stand two groups of high volcanoes belonging to the Fuji volcanic chain, Tateshina and Yatsuga-take on the south, and Myōkō and Yake-yama on the north.

Eastward of the volcanic groups just mentioned, beyond the plain of Chikuma-gawa, there is another line of volcanoes running north and south, in which are the large volcanoes of Asama, Shirane, and Kenashi.

To the east of the Fuji Volcanic Chain, and to the north of the ranges of Misaka and Tanzawa, stretches the nearly square-shaped district occupied by the Kwantō Mountains.. The mountains run from E. S. E. to W. N. W., and are cut off on the east and north-east by the plain of Kwantō. The basin-shaped hollow of Ōmiya lies within the mountains and from it the so-called "Sanchū *Graben*" runs W. N. W. through the narrow valleys of the Sanyama-gawa and the upper Kanna-gawa. To the south of the plain of Kwantō the two hill regions of Miura peninsula and Awa-Kazusa are separated by the Strait of Uraga.

On the north of the plain, mountains run north and south with many longitudinal plains between them.

The eastern coast of Northern Japan is occupied by the two fusiform masses of the Kitakami and Abukuma Mountains and by the small southernmost range of Tsukuba-Yamizo. The Abukuma Mountains commonly known as the Abukuma Plateau, have only a few heights that rise above 1000 m. (Ōtakine-yama 1123 m., Yadaijin-yama 1134 m.). They are bounded on the west by the valleys of Abukuma-gawa and Kuji-gawa and on the east the sea-ward slope is flanked by a long narrow belt of level land. This coast plain continues northward to Sendai, and further northward to the longitudinal depression of the Kitakami-gawa. The mountains running north and south to the west of the Kitakami-gawa, are known as the Kitakami Mountains, the highest peak of which is Hayachine (1996 m.). They have few coast flats and are bounded by a coast of Rias type.

On the side of the Sea of Japan, the Echigo Mountains rise in the east of the volcanic groups of Shirane and Kenashi, near the Shimizu Pass, which crosses the mountains and connects Niigata in Echigo with Maebashi in Kōzuke, and they pass along the western border of Echigo, forming the groups of Iide and Asahi in the north, and are cut on the north by the transverse valleys of the Mogami-gawa. High peaks, above 2000 meters such as Hira-dake, Komaga-take, Kinunuma-yama, Kasa-dake, and Taishaku-zan, cluster where the provinces of Echigo, Kōzuke, Shimotsuke, and Iwashiro meet together.

Between the Echigo Mountains and Kwantō Plain lies the small group of the Ashio Range. It is separated from the Echigo Mountains by the intervening volcanic masses of Akagi and Nikkō.

Two parallel lines of volcanoes run on the western side of Northern Japan. One, called the Nasu Volcanic Zone, commences in Haruna on the east of Asama, and passes north-westward and northward through the volcanoes of Akagi, Shirane (Nikkō), Takahara, Nasu, Azuma, Zaō, Komaga-take, Yakeishi, Ganju, Yatsukōda, and Kamafuse. The other line passes through Gassan, Chōkai, Moriyoshi and Iwaki; it is called the Chōkai Volcanic Zone.

Northern Japan has numerous plains along the coast and in the mountains. The Plain of Kwantō, on the Tone and Sumida, is by far the largest flat in the country. The other important plains are those of Shirakawa and Fukushima on the Abukuma; the plain of the Kitakami; the plains of Aizu, Yonezawa, Yamagata, and of the upper Omono-gawa, between the volcanic chains of Nasu and Chōkai; the plains of Nagano and Niigata on the Shinano-gawa; and the plains of Sakata, Akita, Noshiro, and Tsugaru on the western coast.

The main island of Hokkaidō is traversed in the middle by the back-bone range called the Ezo Mountain Range, which runs N. N. W.—S. S. E., from the cape of Sōya to the cape of Erimo, and bisects the whole island. The main southern portion is called the Hidaka Range; Pipairo (2017 m.), Poroshiri and Satsnaï are the highest peaks. The subsidiary range on the west of the Hidaka Range, which is separated from it by the valleys of the Mukawa and Sorachi, is called the Yūbari Range (Yūbari-dake 1933 m., Ashpetsnupuri 1920 m.). The portion north of the Hidaka Range is greatly augmented by volcanic effusion, and the high peaks, with the exception of Ishikari-dake (2035 m.), are volcanoes, among which Nutapkaushpe (2285 m.), Optateshke (1890 m.), Tokachi-dake (1812 m.), and Teshio-dake (1590 m.) are the highest summits. Northward, the Ezo Mountain Range descends into the low hilly tract of Teshio.

In the western peninsular portion of Hokkaidō, we find the continuation of the volcanic chains of Northern Japan. In particular, numerous volcanic peaks are centered in Iburi Province, Makkarinupuri (1943 m.) being the highest of them.

East of the Ezo Mountains, through the wide tract of low undulations, a volcanic chain passes east and west, connecting westward with the volcanoes in the central part of the Ezo Mountains, and eastward with the line of volcanoes extending through the Kurile Islands, which is known as the

Chishima Volcanic Zone. The highest summits are Meakan (1617 m.), Oakan, Shari, and Kitoushi.

The Islands of Chishima are mainly composed of volcanic rocks and present generally a rugged topography.

PART II.

GEOLOGY.

CHAPTER III.

GENERAL REMARKS.

The lowest stratified rocks composing the Japanese Islands are the Gneiss and the Crystalline Schists Systems of the Archæan Group. The Gneiss System, forming the foundation in the Japanese Islands as elsewhere, consists essentially of gneiss, biotite-schist and granite-gneiss, with associated granite, while the Crystalline Schists System consists of various kinds of phyllitic rocks. The junction between these two systems of Archæan rocks is generally indicated by faults.

Then follows the Palæozoic formation, as seen in the so-called Chichibu System. The earliest fossiliferous rocks in Japan belong to the Carboniferous period. In the upper portion of the Palæozoic there occurs, besides abyssal sediments, a littoral formation predominantly composed of sandstone and clayslate; it is locally known under the name of the Kobotoke System. During the sedimentation of the Palæozoic rocks, intrusions of diorite, gabbro, and diabase occurred. The tuff of diabase was deposited as schalstein, forming thick beds in the Chichibu System. In the close of the Palæozoic era a great tectonic disturbance seems to have taken place, which determined the ground structure of the Japanese Islands.

The Mesozoic formations were next deposited. The representatives of all the three great divisions are found.

The Triassic and Jurassic sediments are limited in extent. The Cretaceous is, however, extensively developed from Kyūshū to Hokkaido and continues to the Island of Saghalien. Protrusions of granite were very frequent in the Mesozoic era. Some of the granite veins intruding into the Palæozoic are covered by the Cretaceous formation, and some cut through the Cretaceous also. In the Mesozoic formation extending through the provinces of Nagato, Buzen, and Chikuzen intercalated porphyrite and beds of porphyrite tuff are found. Gabbro and serpentine frequently make intrusions through the Cretaceous strata.

During the Cainozoic era, especially in Tertiary times, sediments of volcanic ejectamenta formed various kinds of tuffs which are most widely distributed in Northern Japan and Hokkaidō. In the Tertiary age volcanic rocks were erupted in different places; fissures in them were very frequently filled with metalliferous veins, and these are now among the important mineral resources of Japan. That the volcanic activity continued into the Quaternary period, is shown by the volcanic sediments in the Diluvial strata and by numerous volcanic cones, many of which have displayed fearful activity within historical times, and some of which still continue more or less active.

The sedimentary formations and cotemporaneous igneous rocks occurring in Japan may be tabulated in chronological order as follows :—

SEDIMENTARY FORMATIONS.			IGNEOUS ROCKS.
Cainozoic.	Quaternary.	Alluvium. Diluvium.	Andesite, Basalt.
	Tertiary.	Pliocene. Miocene.	Liparite, Andesite, Basalt.
Mesozoic.	Cretaceous.	? Mikura Series. ? Misaka Series. ? Senonian,— Mesozoic of Southern Shikoku. ? Danian—Gault,— Ammonite Beds of Hokkaido and Izumi Sandstone Series. Neocomian,— Ryoseki Series and Torinosu Limestone.	Diorite, Diabase, Porphyrite, Quartz-porphyry, Peridotite, Gabbro. Granite.
	Jurassic.	Bathonian of Inferior Oolite,— Tetori Series. Liassic,— Ammonite bed of Nagato.	Porphyrite.
	Triassic.	Rhaetic,— Plant bed of Yamanoi, Nagato. Juvavic,— Pseudomonotis Beds. Noric,— Ceratites Beds.	Porphyrite.
Palæozoic.	Kobotoke System.		Diabase, Porphyrite, Peridotite, Gabbro.
	Chichibu System	Upper Chichibu Series (Carboniferous). Lower Chichibu Series (Mikabu Series).	
Archæan.	Crystalline Schists System (Sambagawan Series). Gneiss System.		Amphibolite, Serpentine, Granite.

The areas covered respectively by the sedimentary groups and the older and younger igneous rocks are roughly estimated as follows:—

	sq. ri.	% of total area of Japan
Archæan	920	3.40
Palæozoic...	3,446	12.74
Mesozoic	1,935	7.15
Cainozoic...	12,713	46.97
Older Igneous Rocks ...	2,863	10.58
Younger Igneous Rocks...	5,185	19.16
	27,062	100.00

It is clear from the above figures that the area covered by the Cainozoic Group and younger igneous rocks occupies nearly two-thirds of the total area of Japan.

CHAPTER IV.

ARCHÆAN GROUP.

The Archæan Group of Japan is divided into two Systems:—

i. Gneiss System.
ii. Crystalline Schists System.

The Gneiss System resembles in lithological character the Laurentian of North America, and the oldest rocks found in Corea, China, and Siberia. The succeeding system of the Crystalline Schists may correspond to the Argonkian of America or the phyllite complex in Europe. But nothing decisive can be said as regards the correlation, as the oldest fossiliferous series of the Palæozoic group has not yet been found in Japan.

I. GNEISS SYSTEM.

The Gneiss System consists of biotite-gneiss, mica-schists granite-gneiss, amphibole-gneiss, and amphibolites, frequently intercalated with saccharoidal limestone and granulites. Excepting the limestones and mica-schists, the rocks show in several cases the characters of metamorphic eruptive rocks, and it seems that the mica-schists and the crystalline limestone are sedimentaries metamorphosed by the contact action of the metamorphic eruptives. A good example of the appearances that warrant this conclusions is found in the exposures along the Tenryū-gawa.

The distribution of the Gneiss System is confined to the arc of Japan Proper. It is not seen in those of Ryūkyū and Chishima. In Japan Proper the Gneiss System appears in the middle zone, and sporadically, in Oki and Noto, in the inner zone. The rocks of the system have suffered great tectonic disturbances. Granites frequently truncate them in a confused manner, and these granites are treated in many cases as belonging to the Gneiss System.

Hornblende-Gneiss.—This includes the rock which Harada[1] called Kashio-gneiss. Kashio-gneiss is a dark gray to grayish-green rock with more or less schistose structure, Spots of plagioclase and phenocrysts of hornblende are found in a ground mass consisting of quartz, orthoclase, plagioclase, and hornblende. The rock is characterized by the absence of biotite. Harada considered it as a metamorphosed tuff, but the same rock has been observed forming dykes in Awaji and Hida, and hence it may reasonably be considered as a porphyritic eruptive rock.

Common hornblende-gneiss differs from the above. It consists of hornblende, feldspar, and a small quantity of quartz, which are aggregated as in granites, or sometimes more or less linearly arranged when the rock is schistose. Of feldspar, beside the flesh-red orthoclase there is found abundance of plagioclase. Occasionally feldspar and quartz are wanting, and then the rock passes to amphibolite. In the south of Takatō, in Shinano, a lenticular mass of saccharoidal limestone is found intercalated in the gneiss. The hornblende-gneiss contains pyroxene, garnet, and tourmaline near its surface of contact with the limestone, and that portion of it was identified as eclogite by Harada; a portion of the limestone in contact with the hornblende-gneiss contains wollastonite and abundant quartz. The contact phenomena and also the gradual transition of hornblende-gneiss to the eruptive Kashio-gneiss prove the eruptive character of hornblende-gneiss.

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[1] T. Harada: Die Japanischen Inseln. 1890.

Granite-gneiss.—This is the same rock which Kotō, who observed it in the Abukuma Mountains, called schistose amphibole-granite. The rock is dark gray when hornblende predominates and whitish when it lessens. There are different varieties of granite-gneiss showing different grades of schistosity, and augen-gneiss, with porphyritic feldspar, is one of them. As usual constituents, the rock contains plagioclase and biotite. Under the microscope, quartz appears filling the interstices between other minerals. It seems most probable that a gradual transition is to be found between this rock and hornblende-gneiss.

Biotite-gneiss.—This consists of quartz, feldspar, and biotite. Some of the rock shows the structure of schistose granite and is Kotō's schistose biotite-granite. Other parts contain biotite of a dark brownish purple colour, just like biotite found in biotite-schist and contact rocks; this variety

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[1] B. Kotō: The Archæan Formation of the Abukuma Plateau. Journ. Col. Sci. Imp. Univ., vol. V, 1893.

of biotite-gneiss is developed only near places of contact with biotite-schist.

Biotite-schist.—This rock consists of biotite and quartz, frequently with feldspar, and is Kotō's gneiss-mica-schist. When mica decreases, the rock looks like quartzite. Garnet occurs frequently as an accessory.

We shall now describe the local occurrences of the Gneiss System.

Tenryū-gawa Region.—The so-called Akaiishi fissure-line marks the contact of the Gneiss System of this region with the two Systems of the Crystalline Schists and the Palæozoic, which here lie east of the Gneiss System. The strike of the schistose plane of the gneiss, as developed here, is parallel to the above geological boundary line, and the dip is steeply toward the west. If we consider the schistose plane as the plane of stratification, the rocks near the fissure-line must be of lower horizon than those which are distant from it. In this way Harada established the stratigraphical succession of the Gneiss System in this region. According to him, the lowest strata consist of porphyritic Kashio-gneiss, overlaid by hornblende-bearing biotite-gneiss; the latter is intercalated with limestone and eclogite. The next upper layer consists of granite-gneiss which has a wide distribution; it contains layers of biotite-schist and biotite-gneiss and is frequently cut by dykes of granulite. The Gneiss System, as seen in Mikawa, between the Yahagi-gawa and the lower Tenryū, has a north-east strike. Here is found the continuation of the Kashio-gneiss developed in the eastern part of the Ina Range, which is covered by the Tertiary formation of Shidara district. On the west of the zone of Kashio-gneiss, the complex of biotite-schist and biotite-gneiss predominates; and these latter rocks are cut by dykes of granite.

Kii Peninsula.—In the Gneiss System forming the northern part of the peninsula, the strike is N. E. in the north-eastern part and E.—W. in the western half. The rocks are essentially mica-schist and granite-gneiss, with intercalations of limestone. The limestone in contact with granite-gneiss frequently contains pyroxene and garnet. Hornblende-gneiss is only insignificantly developed.

Hida Plateau.—The Gneiss System in Hida and the northern part of Etchū has a N.N.E. strike, which changes to nearly N. E. in the south-western portion of the plateau. The rocks are predominantly gneiss and hornblende-gneiss, and subordinately granite-gneiss and limestone. Rarely the gneiss contains graphite, as in the eastern part of Amō Pass. Hornblende-gneiss in the plateau frequently shows a porphyritic structure with large specks of flesh-red feldspar scattered in a dioritic ground-mass; hypersthene predominates sometimes in the rock, which then passes into norite. The hornblende-gneiss in the upper Tetori-gawa is intercalated with biotite-gneiss and limestone layers and cut by granite.

Abukuma Plateau.—An area of the Gneiss System far larger than those described above is found in the Abukuma Plateau. Kotō made a study of the formations in the central part of the mountains and classified them as follows:—

Upper {
1. Gozaisho Series (Amphibolites)
2. Takanuki Series (Mica-schists, Amphibole-schists)
Lower 3. Laurentian (Schistose granites)

As a greater part of the Gozaisho Series corresponds to the amphibolites of the Lower Chichibu Series, the area of the series is coloured on the map as Palæozoic.

Hornblende-granite plays the most important rôle in the Gneiss System of the Abukuma Plateau. It is a dark gray rock containing abundant plagioclase and hornblende, besides quartz, orthoclase, microcline, and biotite; it constitutes the very foundation of the system. The biotite-granite is light-coloured and contains flesh-red orthoclase, quartz, biotite and a small quantity of plagioclase and muscovite. This rock is seen cutting through hornblende-granite and sometimes contains black patches of the latter rock caught up and enclosed in it. Mica-schists occur in several varieties, as gneiss-mica-schist or Ryōke mica-schist, two-mica-schist, garnet-biotite-schist, etc. The essential components are biotite and quartz; feldspars, muscovite, and garnet occur subordinately. The gneiss-mica-schist, rich in quartz and feldspar, looks like sandstone, and one variety with abundant quartz and but little mica presents the aspect of quartz-schist. Biotite-schist is the most prevalent of the mica-schists. Amphibole-schists, intercalating with mica-schists, are called titanite-amphibole-schists. They are black, highly crystalline schists, with alternations of very thin light coloured layers. The black zone consists of hornblende, plagioclase, and biotite, and the light-coloured zone consists mainly of light-green pyroxene.

Near Machiya in the southern end of the plateau are outcrops of hornblende-gneiss and amphibole-schists, resembling the hornblende-gneiss of Ina in the Tenryū-gawa region. They are cut by schistose granite, and they are unconformable with an alternation of biotite-schist and amphibole-schist which also occur there.

Crystalline limestone is largely exposed in Ōtakine-yama and Hayama in the central part of the plateau; the peripherical portions of the limestone contain contact minerals such as pyroxene and garnet. Limestone with abundant garnet is also found in the Gneiss System forming the base of the volcanic group of Azuma.

North of the Abukuma Mountains, granite-gneiss is found in small patches in Rikuzen and near the Sennin Mine in Rikuchū.

Coasts of the Inland Sea.—The Gneiss System outcrops on the northern and southern coasts and islands of the Inland Sea. A good outcrop of folded mica-schist, hornblende-gneiss and Kashio-gneiss, cut by granite, is seen on the eastern coast of Awaji, where dykes of norite with a large proportion of hornblende are found in allanite-bearing hornblende-gneiss. The Gneiss System constituting the islands in the Bingo-nada consists of biotite-schist and biotite-gneiss with limestone. Ōshima at the south end of Suō consist mainly of granite-gneiss with intercalating limestone.

Island of Oki.—Two-mica-schist, hornblende-gneiss, granite-gneiss compose the foundation. The strike is N.—S., and the dip W.

Kyūshū.—The petty outcrop of the Gneiss System amid the volcanics in Bungo consists of biotite-gneiss and biotite-schists with a N. N. E. strike.

In the environs of Kumamoto occur hornblende-gneiss and granite-gneiss with subordinate biotite-schist and limestone. The rocks south of Kumamoto strike N. N. W. in the east and S. W. in the west; and those north of the city have a N. W. strike with a high dip to N. E.

II. CRYSTALLINE SCHISTS SYSTEM.

The name of the Crystalline Schists System was first applied by Edmund Naumann[1] to a group of metamorphic schists petrographically and stratigraphically distinct from the gneissic schists, and subsequently B. Kotō[2] proposed the name of the Sambagawan Series, the same series of rocks occurring in the Sambagawa region in Chichibu in the Kwantō Mountains. The system consists of various schists of a phyllitic aspect with the characteristic components of sericite, chlorite, epidote, and calcite. They are accompanied by eruptives such as serpentine and gabbro, but not by granitic eruptives. Although the rocks of the Crystalline Schists System are clearly distinguishable from those of the Gneiss System (with the exception of amphibole-schist in the chlorite-schist series, a rock allied to which occurs in the Gneiss System), the distinction between the Crystalline Schists and the lowest series of the Palæozoic consisting of amphibolite, pyroxenite, and graphitic phyllite is not always clearly defined.

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[1] Ueber den Bau und die Entstehung der japanischen Inseln, 1885.

[2] On the so-called Crystalline Schists of Chichibu. Journ. Col. Sci. Imp. Univ., II, 1889

The rocks of the system are distributed over Honshū, Shikoku, Kyūshū, Hokkaidō, Taiwan, and the Ryūkyū Islands. In the distribution of the Crystalline Schists three belts are observed: First, those schists developed in the outer zone of the arc of Japan Proper, namely in the mountains of Kwantō, Akaishi, Kii, and Shikoku, and through the middle of Kyūshū; second, those in the inner zone of the same arc, namely, those stretching through the western portion of Chūgoku, and the Tsukushi Mountains and to Hizen; and third, those in the outer zone of the Ryūkyū arc, namely those found in the eastern portion of Taiwan and in the islands of Okinawa and Ishigaki-jima in the Ryūkyū Group.

Kwantō Mountains.—The Crystalline Schists System comprises the oldest rocks in these mountains. The rocks of the system are exposed in a thin zone in the north-eastern margin of the mountains with a strike approximately N.W.—S.E. Kotō opened the way for the study of the crystalline schists by a detailed investigation of the rocks of the system in the Chichibu district, which are classified by him as follows:—

Upper Sambagawan,——epidote-sericite-gneiss.
Middle Sambagawan,——spotted graphite-schist and spotted chlorite-schist.
Lower Sambagawan,——normal sericite-schist.

The rocks of the Sambagawan Series have a close resemblance to the so-called 'Canana Schiefer' of the Alps, and to the sericite-gneisses and sericite-schists of the districts of Nassau and Taunus in Germany.

Normal sericite-schist is a grayish-white, thick foliated rock consisting of quartz, feldspar, sericite, calcite, and rutile, with accessory minerals including epidote, light green garnet, rarely occurring piedmontite, iron-mica, pyrites, and sometimes magnetite.

Piedmontite-schist occurs in the horizons near the boundary of the Lower and Middle divisions. Being a characteristic, beautiful purplish rock it serves as a good mark in the stratigraphy of the schists complex. It contains piedmontite, quartz, sericite, yellowish-green garnet, rutile, feldspar grains, etc.

Spotted graphite-schist is a nearly black thinly schistose rock with black spots. It consists essentially of feldspar, sericite, graphite, hæmatite, and quartz, with accessory tourmaline, garnet, and rutile. The weathered rock has the aspect of a brown mica-schist and in an advanced stage of decomposition it becomes even talcose in appearance. The spots consist of feldspar containing graphite, garnet, rutile, etc.

Spotted chlorite-schist or chlorite-amphibolite is an imperfectly schistose, green rock with innumerable white spots. It strikingly resembles the chlorite-schist of the 'Grünschiefer System' of Saxony. The green colour of the rock is imparted by chlorite, besides which the rock contains epidote, actinolite, calcite, hæmatite, pyrites, and rarely quartz and rutile. The white dots are feldspar, with abundant interposition of epidote, some actinolite and tourmaline, and sometimes garnet.

Alternations of the rocks of the above two types constituting the Middle Sambagawan Series attain a considerable thickness, forming the main bulk of the Crystalline Schists System not only in the Kwantō Mountains but in other regions as well.

Epidote-sericite-gneiss is a more or less platy rock with an uneven surface on a cleaved specimen. It is sometimes graphitic and with the increase of sericite it becomes a thin, papery schist. It consists essentially of quartz, feldspar and sericite, with epidote, garnet, and tremolite as accessories.

Tenryū-gawa Region.—A narrow belt of the Crystalline Schists System is exposed in the valleys of the Mibū-gawa and Misakubo-gawa, the tributaries of the Tenryū, and on the lower course of the Tenryū, on the western side of the Akaishi Mountains. In the vicinity of Misakubo, there is an outcrop showing an alternation of spotted chlorite-schist and spotted graphite-schist with piedmontite-schist in the lower horizons. They are overlaid by graphitic phyllite. Near Nishido on the lower course of the Tenryū a wide exposure of graphitic phyllite is seen. A thick, bedded mass of pyritic copper ore is found at Kune in the crystalline schists of the district.

Abukuma Mountains.—A good exposure of a thick series of dark-green schistose rocks, designated as the Gozaisho Series by Kotō, may be seen on the eastern part of the highway between Taira and Shirakawa in Iwaki. This exposure is in the valley of the Same-gawa in the central part of the mountains. The rocks closely resemble the amphibolite in the lowest series of the Palæozoic and are mapped as such. Near Kami-misaka occurs chlorite-schist with piedmontite, which may belong to the Crystalline Schists System.

Kii Peninsula.—The Crystalline Schists System exposed south of the Kino-kawa consists of glaucophane-schist, normal sericite-schist, quartz-schist, and piedmontite-schist in the lower portion, and spotted chlorite-schist and spotted graphite-schist in the upper. They are overlaid by graphitic phyllite and pyroxenite of the Lower Chichibu Series.

Shikoku.—The Crystalline Schists System attains a full development in the island, forming the protaxis of the Shikoku Mountain Range. Here the rocks are more varied than those of the Kwantō Mountains and the stratigraphical successions differ somewhat from those in the latter. T. Suzuki established the following grouping of the Crystalline Schists System in the vicinity of Tokushima, at the mouth of the Yoshino-gawa:—

Upper.——Epidote-gneiss, graphite-gneiss, sericite-gneiss.
Middle.——Spotted chlorite-amphibolite, spotted graphite-schist.
Lower.——Sericite-schist, piedmontite-schist, glaucophane-schist.

The middle series has the widest distribution here, as in other regions. Glaucophane-schist and sericite-gneiss are characteristic rocks not found in the Kwantō and Tenryū regions.

Glaucophane-schist is a beautiful foliated rock of grayish-blue to purplish-blue colour, the colour being due to the presence of macroscopic indigo-blue glaucophane in long, flat prismatic forms. The rock contains, besides glaucophane, epidote, garnet, quartz, some feldspars, rutile, specular iron, and piedmontite. It occurs in the horizons near those of piedmontite-schist. The mineral glaucophane is found in small quantity in other members of the Crystalline Schists System in Shikoku, such as sericite-schist, piedmontite-schist, and chlorite-schist.

Sericite-gneiss, known also as Ōboke gneiss, is a platy rock of a grayish colour, and has the aspect of a schistose modification of graywacke-sandstone. It consists of quartz, orthoclase, plagioclase, sericite, and epidote. It is typically developed in the gorge of Ōboke in Awa, in the transverse valley of the Yoshino-gawa.

In the transverse valley of the Yoshino-gawa between Ikeda on the north and Shimo-myō on the south, rocks of the Crystalline Schists System are developed in full proportions. Near Ikeda the outcrop is predominantly piedmontite-schist, glaucophane-schist, spotted chlorite-schist and graphite-schist, and south of Nakanishi appear chlorite-schist and a thick series of graphite-schists; all the rocks dip northward. In the Ōboke gorge between Nishi-u and Kami-myō sericite-gneiss looking like a crushed graywacke-sandstone forms an anticline, and southward from there graphite-schist and chlorite-schist are again exposed. The accompanying figure represents a section across the protaxis of the Shikoku Mountains by way of the Itase Pass, 20 km. west of the transverse valley of the Yoshino-gawa.

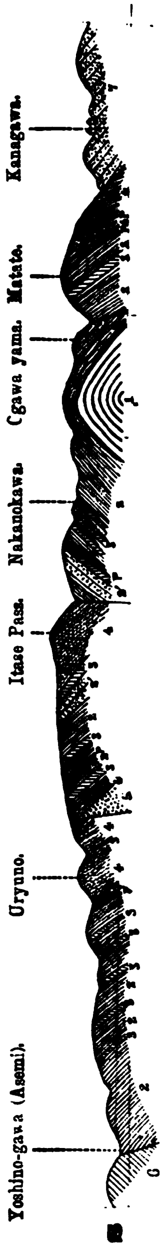

Fig. 1.—Section across the Crystalline Schists System of Shikoku from Kanagawa in Iyo to Asemi in Tosa. 1:200,000. (After Ogawa.)
1. Ōboke gneiss. 2. Graphite-schist. 2'. Spotted graphite-schist. 3. Chlorite-schist. 4. Sericite-schist. 5. Garnet-amphibolite. 6. Lower Chichibu Series. 7. Izumi Sandstone Series. P. Piedmontite-schist.

Further westward a good outcrop of schists all dipping northward is found along the railroad cutting north of the Besshi Copper Mines. The succession of outcrops is as follows, in the descending order.

1. Graphitic schist, in the northern margin of the schist mountain; 2. spotted chlorite-schist and sericite-schist with several zones of piedmontite-schist and graphite-schist; 3. garnet-amphibolite with layers of piedmontite-schist and garnet-sericite-schist; 4. sericite-schist with piedmontite-schist; 5. alternation of spotted graphite-schist and spotted chlorite-schist which contains a few layers of piedmontite-schist, near the horizon of the pyritic

copper deposit of Besshi. Southward of Besshi we see also thick strata of graphite-schist and chlorite-schist.

Garnet-amphibolite, the eclogite of Oebecke, is a beautiful, dark greenish, schistose rock with red garnet and sericite in the plane of schistosity. The rock contains, besides those macroscopic minerals, dark bluish-green hornblende, allanite, and a little quartz. The rock seems to be a metamorphosed eruptive.

The above-mentioned successions of rocks do not agree with those of the environs of Tokushima or of the transverse valley of the Yoshino-gawa. Whether we have here to regard the whole thick bed as displaying the normal succession, or as an inversion, we have no sufficient data to determine for the present.

The strike of the crystalline schists in Shikoku varies between N. E.—S. W. and N. W.—S. E., and the lines of the strike do not coincide with the directions of the geological boundaries.

Kyūshū.—The Crystalline Schists System reappears on the other side of Bungo Strait in the neighbourhood of Saganoseki and there consists mainly of graphite-schist with subordinate chlorite-schist, and rarely thin limestone. The strike is E. N. E.—W. S. W. forming an anticline.

The small outcrop of crystalline schists near Takahama, in the western portion of the Amakusa Islands, consists of sericite-schist and overlying spotted graphite-schist and spotted chlorite-schist. The strike is N. 40° W. and the dip about 30° N.E.

The rocks of this system in the Sonogi Peninsula in Hizen consist predominantly of graphite-schist and subordinately of chlorite-schist and glaucophane-schist.

In northern Kyūshū graphite-schist and spotted chlorite-schist make a small outcrop near Fukuoka, forming an anticline; they are covered by amphibolite of the lower Chichibu Series.

Chūgoku.—Small outcrops of crystalline schists found in Iwami, Suō, etc. seem to differ somewhat from the normal types. Those near Hamada in Iwami consist of rocks like epidote-schist and graphite-phyllite and sometimes contain limestone; they look like metamorphosed Palæozoic rocks.

Ryūkyū.—Our knowledge of the Crystalline Schists System of the Group is meagre. The exposures in Okinawa Islands and in Ishigaki-jima seem to be mainly graphite-schist and chlorite-schist.

Taiwan.—A long belt of crystalline schists, exposed along the eastern side of the axial range, on the west of the longitudinal valley of Taitō, consists of graphite-schist, chlorite-schist, and sericite-schist. The strike is, in conformity with the trend of the Taiwan Mountain Range, E.—W., with a northward dip, in the extreme north, and turns nearly N.—S. in the south, with a westward dip. A thick crystalline limestone forms the intermediate zone between the Crystalline Schists System and the Palæozoic.

Hokkaidō.—The Crystalline Schists System is not indicated on the geological map of Hokkaidō. But, according to K. Jimbō,[1] rocks of the system, such as glaucophane-sericite-schist, garnet-amphibolite, graphite-schist, chlorite-schist, etc. have been found sporadically, in scanty exposures and as river pebbles, in a few localities on the eastern flank of the Ezo Mountains.

CHAPTER V.

PALÆOZOIC GROUP.

The Palæozoic Group covers large areas both in the inner and outer zones of Japan, composing a greater part of the mountain masses of the country. The rocks consist of a series of formations of an enormous thickness. Upper Carboniferous or Permo-carboniferous fauna are the only fossils of stratigraphical importance occurring in the Palæozoic of Japan, and they are restricted within very narrow zones. As fossils can be but little used in the classification of the thick series, the only data for the divisions of the group are order of superposition and lithological character.

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[1] General Geological Sketch of Hokkaidō, 1892.

E. Naumann divided the Palæozoic of Japan into two subdivisions, the older and the younger. T. Harada and others recognized a two-fold division in the Kwantō Mountains and adjoining regions, namely the Chichibu System and the Kobotoke System. The Chichibu System appears directly in contact with the Archæan formation and the Kobotoke System comes next on the outer side of the Chichibu System; and consequently the Kobotoke System is considered as younger than the Chichibu System. Naumann's two subdivisions correspond, with the inversion of the stratigraphical order, to the abovementioned two systems; that is to say, the transition formation, the older division of Naumann, is identical with the Kobotoke System, and his younger division is identical with the Chichibu System. However, the two-fold division has not been found applicable all over the Palæozoic of Japan. The Kobotoke System has been recognized only in limited areas, namely, in the mountains of Kwantō, Ashio, Tsukuba-Yamizo, Akaishi, and Kiso.

1. STRATIGRAPHY AND LITHOLOGY.

I. CHICHIBU SYSTEM.

The Chichibu System is commonly divided into three, the Upper, Middle, and Lower Chichibu Series. The main features of the divisions are observable in nearly all Palæozoic regions, but they are subject to local variation, as seen from the following examples:

Chichibu district of Musashi in the Kwantō Mountains:—

Upper
1. Hornstone, clayslate, sandstone
2. *Fusulina* limestone
3. Upper adinole slate, hornstone (radiolarian slate), schalstein

Middle
4. Adinole slate, hornstone (radiolarian slate).
5. Graywacke sandstone, clayslate
6. Lower schalstein, quartzite, adinole slate, limestone with crinoids and corals
7. Adinole slate, radiolarian slate
8. Red and green quartzite

Lower
9. Pyroxenite, amphibolite, serpentine and gabbro.

Ōno district in Echizen, in the west of Hida Plateau (according to S. Matsushima):—

Upper
1. *Fusulina* limestone
2. Upper schalstein (conglomeratic in the lower part)

Middle
3. Red calcareous sandstone, conglomerate
4. Graywacke sandstone, clayslate
5. Lower schalstein, limestone, adinole slate, quartzite
6. Quartzite

Lower
7. Pyroxenite, gabbro-diorite.

The Island of Shikoku:—

Upper
1. Sandstone, clayslate
2. *Fusulina* limestone
3. Green schalstein, radiolarian slate with lenticular masses of limestone

Middle
4. Black clayslate, graywacke sandstone
5. Hornstone, quartzite
6. Clayslate, graywacke sandstone
7. Red and green schalstein, limestone with crinoids
8. Clayslate, graywacke sandstone
9. Quartzite

Lower 10. Graphitic phyllite, limestone, pyroxenite (agglomeratic in part).

The western portion of the Kyūshū Mountain Range (according to T. Suzuki):—

Upper
1. Black silicious slate, radiolarian slate, green and brown schalstein, *Fusulina* limestone
2. Graywacke sandstone, clayslate, hornstone

Middle
3. Schalstein, green slate
4. White, red, and green platy quartzite

Lower 5. Pyroxenite, amphibolite, limestone.

The eastern part of the Kyūshū Mountain Range (according to K. Nakashima):—

Upper 1. Schalstein, hornstone, clayslate, graywacke sandstone, *Fusulina* limestone

Lower 2. Clayslate, graywacke sandstone, (rarely with radiolarian slate, schalstein, adinole slate).

The Kitakami Mountains (according to K. Jimbō):—

1. Clayslate
2. Graywacke sandstone, clayslate (with 2 zones of limestone with Carboniferous fossils)
3. Clayslate
4. Conglomerate (with pebbles of granite, hornstone, graywacke sandstone, etc.), graywacke sandstone, clayslate
5. Schalstein, radiolarian slate.

1. *Lower Chichibu Series.*

This is otherwise known as the Mikabu Series or Kasayama Series. The rocks consist mainly of pyroxenite with subordinate layèrs of amphibolite and phyllite. The pyroxenite is a compact to fine-grained, gray or dark green rock, more or less stratified, consisting essentially of pyroxene. Under the microscope the pyroxene is light brown, a little pleochroic, and is often changed by dynamo-metamorphism to fibrous amphibole and further to chlorite or epidote, sometimes to glaucophane as in the pyroxenites of Nakakubo in Kōzuke and Ishi district in Shima. In an agglomeratic variety of pyroxenite, fragments of rocks of various sizes are contained in a grayish green ground-mass. The included rock-pieces are macroscopically dark gray and compact; under the microscope they show a hyalopilitic structure, and contain pseudomorphs of tremolite, chlorite, etc. after feldspar, pyroxene and olivine, as in the pyroxenites of Ise, western Kii, and Tosa.

The pyroxenite of which Kasayama in the eastern part of the Kwantō Mountains principally consists, (whence the name of the "Kasayama Series") contains a glassy substance in thin lenticular form, which shows clearly a fluidal structure. Pyroxenite of this kind might have been derived from mud-lavas by metamorphism.

The Lower Chichibu Series composing the southern part of the Abukuma Mountains consists of thick beds of amphibolite, with subordinate layers of clayslate and metamorphosed mica-schist. The amphibolite has several zones of amygdaloidal vesicules filled with quartz in the planes of schistosity, which show the probable original nature of the rock. In short, the original rocks of these various pyroxenites were probably lavas, mud-lavas, tuffs, or volcanic agglomerates.

Crystalline limestone, quartzite, and graphitic phyllite nterstratify with pyroxenite. The graphitic phyllite of this series is with difficulty distinguished from the graphite schist of the Crystalline Schists System.

2. *Middle and Upper Chichibu Series.*

These consist of schalstein, sandstone, clayslate, quartzite, hornstone, radiolarian slate, limestone, etc., and commonly rest conformably on the Lower Chichibu Series. The thickness of these individual rocks is subject to great variation.

The details of stratigraphical succession of the series vary in different parts of the country. But the easily recognizable and almost never failing rocks, such as crumpled quartzite and hornstone of various colours, adinole slate, schalstein with limestone, radiolarian slate, and *Fusulina* and crinoidal limestones, are marks of correlation. The fossiliferous limestones and clayslates occur only in the upper horizons. In Chichibu they are accompanied by schalstein, and *Fusulina* occurs above the crinoid zone. In Rikuzen the zone of *Lyttonia* with *Fenestella, Spirifer*, crinoids, etc. occupies the uppermost fossiliferous horizon; next comes the *Phillipsia* zone with *Phyllipsia, Spirifer, Rynchonella, Fenestella*, etc.; and it is underlaid by limestone with *Fusulina* and *Schwagerina.*

The quartzite consists of a grayish white, red or green aggregate of granular quartz. It is massive or thinly platy, often contorted. Sometimes it contains remains of *Radiolaria.*

The hornstone is commonly platy, sometimes massive. It usually accompanies quartzite and often passes into it.

The adinole slate is a platy, regularly cleavable rock consisting of an aggregate of quartz and feldspar with mica and epidote as accessories. It is greenish gray or yellowish green, but becomes brownish red and more or less fibrous by weathering.

The graywacke sandstone is a medium or fine-grained, dark gray rock. It alternates with clayslate, adinole slate being intercalated. The clayslate that overlies the *Fusulina* limestone of the Kitakami Mountains contains casts of Trilobites, bryozoans, brachiopods, corals, crinoids, etc.

The schalstein is of various kinds. It is fine-grained and more or less platy, coarse-grained, agglomeratic, or brecciated. The colours are green or reddish brown. It consists of feldspar and augite with accessory calcite, epidote, pyrite, and hæmatite. The augite often alters by weathering into a fibrous, chloritic substance, or else into glaucophane.

Radiolarian slate appears more frequently in the Upper Series and is often accompanied by schalstein. It is silicious, compact, platy, usually brownish red. It gradually passes into quartzite, hornstone, or sandy clayslate. It contains usually very imperfect remains of *Radiolaria.*

The crinoidal limestone, which often accompanies the lower schalstein, is white, gray, or reddish gray, rarely crystalline.

The *Fusulina* limestone, which is characterized by *Fusulina* and *Schwagerina*, constitutes the uppermost horizon of the Upper Chichibu Series and is the most important of all Palæozoic rocks, as it is the sole widely spread representative of the Carboniferous group found in Japan.

According to B. Kotō, the Carboniferous limestone of Akasaka in Mino is divisible into eight beds which are as follows:—

1. Brecciated limestone, composed of fragments of the limestones below it.
2. Black marble, containing *Bellerophon*, *Murchisonia.*

Upper	3. Black earthy limestone, containing *Schwagerina* and corals, the former distributed throughout the rock, while the latter occurs in only a part of it. 4. Black limestone, traversed by small veins of calcite, and poor in fossils, only rarely containing crinoids, *Fusulina*, and *Schwagerina* in some parts.
Lower	5. Dark gray limestone, hard and compact, with a few large specimens of *Fusulina*. 6. *Kasumi-ishi*, a white limestone rich in fossils: large *Fusulina*, *Pleurotomaria*, corals, 2 crinoids, and small *Bellerophon*. 7. *Same-ishi*, a hard, compact, gray limestone rich in fossils: abundant *Fusulina japonica* and bivalves. 8. White crystalline limestone, fossilless.

The upper division is characterized by *Schwagerina*, the lower by *Fusulina*, while large *Bellerophon* and abundant corals are found in the upper, and crinoids are common in the lower division.

Kotō observed that in the limestones of Samegai and Nagaoka in Ōmi, and Tsukitate in Rikuzen, only the lower division is represented; while in that of Kesennuma in Rikuzen only the upper is represented.

In the Kwantō Mountains there are two zones of *Fusulina* limestone which run parallel to each other, one on the north and the other on the south of the Cretaceous '*Graben* of Sanchū.' The northern one runs from Bishamon-yama, N. W. of Sanyama, to the Tano district, while the southern one ranges erom Hibara, N.W. of Itsukaichi, to Nippa through Niegawa In the Akaishi Mountain Range several beds of limestone are exposed, but *Fusulina* is not known to exist in them. In-

Kii, a limestone containing pebbles with *Fusulina* is found on the Arita-gawa. In the Shikoku Mountains a *Fusulina* limestone bed stretches through the middle of the island. Kyūshū has two zones of *Fusulina* limestone; one appears in Nishi Usuki District in Hyūga and stretches to Nishime in Satsuma, and the other at Kawamata and Sashiki in the neighbourhood of the Triassic of Higo.

Limestone occupies pretty large areas in the outer zone of Southern Japan. In the northern Hida Range, limestone extends from Myōjō-yama in Echigo to Kurohime-yama. In the south-western part of Hida Plateau, where the strata are greatly disturbed, limestone appears in patches. Thick beds of limestone are seen near the boundaries of the provinces of Mino, Ise, and Ōmi, as at Akasaka and Yōrō in Mino, Ibuki-yama, Samegai, Gotō, and Kurakake-yama in Ōmi and Fujiwara-take in Ise.

In the limestone of Akasaka the following fossils have been found[1]:—

Fusulina japonica, GÜMB.
„ *exilis*, SCHWAGER.
Schwagerina Verbeeki, GEINITZ.
„ *craticulifera*, SCHWAGER.
Fusulinella sp.
Lingulina sp.
Tetrataxis conica, EHRENBERG.
Endothyra cf. *crassa*, BRADY.
Climacammina protenta, SCHWAGER.
„ *cribrigera*, SCHWAGER.

besides *Archæocidaris*, *Poteriocrinus*, *Pentacrinus*, *Favosites*, *? Cyathophyllum*, *Pleurotomaria*, *? Murchisonia*, *Bellerophon aff. hiulcus*, *Endothyra*, *Trochammina*, *and Textularia*.

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[1] Schwager. Richthofen, China, IV. Band. Gottsche, Zeitsch. d. deutsch. geol. Gesellschaft, 1884.

In Tamba Plateau limestone is exposed in Takao-yama in Yamashiro, Kannon-take in Tamba and in Shizumi, N.W. of Kobama, in Wakasa. In Chūgoku it also occupies a large area, *Fusulina* being sometimes found in it. *Fusulina* limestone is also found in the environs of Setamae, in the Kitakami Mountains, but it is not yet known to exist in Hokkaidō and Taiwan.

II. KOBOTOKE SYSTEM.

The Kobotoke System is composed chiefly of clayslate, graywacke sandstone, quartzite and conglomerate. Limestone and schalstein which are abundantly found in the Chichibu System, are very rarely met with in the formation.

The clayslate well exposed at the Pass of Kobotoke west of Tōkyō was first recognized as a special formation; hence the name of the system.

This clayslate is commonly dark gray and carbonaceous. It passes into quartzite, sandstone, and phyllite.

The graywacke sandstone is fine or medium-grained and of various shades of dark gray. It is rarely conglomeratic or brecciated, and when highly silicious it resembles quartzite.

No fossils except a few indeterminable plant remains have been found in the Kobotoke System. In some parts it is considered as representing an uncommonly thick developement of a zone in the upper part of the Chichibu System.

II. LOCAL DESCRIPTIONS.

Kwantō Mountains.—The Palæozoic of the Kwantō Mountains appears south of the Archæan zone, consisting of the Sambagawan Series. The formation which constitutes the main part of the Mountains is divided by a line drawn W. N. W. from Hachiōji to Tamba-yama into two areas; the rocks in the northern area are known as the Chichibu System and those in the southern as the Kobotoke System. The rocks and their stratigraphical succession have been already described. The strata are folded into many synclines and anticlines with a general strike to the N. W. Several zones of limestone are found in the Chichibu System.

Akaishi Range.—The western portion of the range is composed of rocks of the Lower Chichibu Series, which dip to the west, while the eastern shows the Middle and Upper Series which are folded into many synclines and anticlines. The Kobotoke System is developed on the south eastern fringe. A large anticline passes through the north-east of Akaishi-yama and the west of Kurobōshi-yama, the direction being N. N. E. West of the anticline, a long persisting syncline runs parallel to it. The hilly tract near the boundary of Tōtōmi and Mikawa, S. W. of the Akaishi Mountains, is composed of pyroxenite, schalstein, and limestone.

Kii Peninsula.—Pyroxenite and graphitic phyllite of the Lower Chichibu Series are exposed only in the northern part of the peninsula next to the Gneiss and Crystalline Schists Systems; while rocks of the Middle and Upper Series compose the southern part. *Fusulina* limestone is found at Itokawa, in Aritagawa District. No sharp line of distinction between the Palæozoic and the Mesozoic on the south of it has yet been observed. The general strike is N. E.

Shikoku.—The Palæozoic formation here consists of rocks nearly identical with those of the Chichibu System of the Kwantō Mountains. The distinction between the Lower Chichibu Series and the Crystalline Schists is not clearly defined. The same is the case also with the boundary between the Palæozoic and the Mesozoic as is seen especially in the environs of Sakawa in Tosa where the areas of *Fusulina* limestone, and Triassic and Cretaceous beds occur closely mingled together. The strike coincides with the general trend of the Island.

Kyūshū Mountain Range.—The stratigraphy of the Kyūshū Range has been given before. Pyroxenite with limestone is found north of the Archæan instead of south of it as in the cases above-mentioned. Crinoidal limestone occurs near the line of contact with the Gneiss system. The strike is N. E.—S. W.

Hida Plateau.—The rocks consist of quartzite, adinole slate, clayslate, schalstein with crinoidal limestone, radiolarian slate, hornstone and thick *Fusulina* limestone. The Lower Series is not found. The strike is W. N. W. in the north and gradually changes to N.—S. in the south. It is N. E. in the valley of Kisogawa.

Tamba Plateau.—The rocks belong to the Middle and Upper Chichibu Series, and are similar to those of Hida Plateau. The Strike is E. N. E. in the north, N. E. in the east and N. W. in the west. *Fusulina* limestone occurs in thick beds.

Chūgoku.—The Palæozoic occurs irregularly in patches among eruptives. It consists of the Middle and Upper Series. Schalstein and tuffaceous clayslate form thick beds. Limestone with *Fusulina*, *Schwagerina*, brachiopods, etc. occurs as thick beds and covers large areas, as in the Palæozoic N. W. of Okayama in Bizen and N. of Akiyoshi in Nagato. The formation which has been regarded as belonging to the Crystalline Schists, on the northern side of the Chūgoku Mountains and in Suō, consists of rocks like metamorphosed phyllite and amphibolite, and may probably be a part of the Lower Chichibu Series. In Iwami a zone of light gray compact or crystalline limestone, extends through the country and reaches to Zōmeki in Nagato.

Tsukushi Range in Kyūshū. — Amphibolites, with subordinate layers of limestone and mica-schist, are the main rocks. Often they resemble very much the amphibolite-schists of the Archaean. But south of the Chikugo-gawa quartzite, clayslate, and schalstein are developed.

Chōshi Peninsula in the eastern extremity of the Plain of Kwantō. The small outcrop here of the Palæozoic formation from under the Tertiary consists of clayslate, graywacke sandstone, limestone, hornstone, and radiolarian slate. The strike is N. N. W.

Echigo Mountains.—The Palæozoic is here separated into many small areas by the later irruption of granite and other eruptives or by the covering of younger strata. The rocks are mainly graywacke sandstone and clayslate of the Kobotoke System. Limestone is rarely found. *Fusulina* limestone occurs at Kuzu in Shimotsuke and Mizunuma in Kōzuke. A specimen of *Helicoprion*, teeth of an elasmobrachian fish has been found in the Crinoidal limestone at a limestone quarry south of the Ashio copper mine, in Kōzuke. It closely resembles *H. Bessonowi* KARPINSKY, found in the Permo-Carboniferous Artinsk formation of Russia. The Lower Chichibu Series is limited to a small area east and north of Numata in Kōzuke. In the Echigo Mountains the strata are much disturbed but N. E. and N. W. strikes are prevalent.

Tsukuba-Yamizo Range.—The rocks are clayslate and sandstone of the Kobotoke System. The strike is N. W. in the northern part and N. E. south of Torinoko-yama. In the southern part the rocks are much metamorphosed by the eruptives of Tsukuba and they are with difficulty distinguishable from the Archæan gneiss of the Abukuma Mountains.

Sado Island.—The Palæozoic of two small areas belongs to the Middle Chichibu Series, and consists of schalstein, clayslate, graywacke sandstone, and hornstone.

Abukuma Mountains.—The chief rocks are amphibolites which correspond with the pyroxenite of the Lower Chichibu Series of other regions. The amphibolites form Kotō's "Gozaisho Series." The amphibolites become more crystalline as they approaches the Gneiss System of the west, and it is often difficult to mark the distinction between these two systems. In the southern part a fine, white crystalline limestone is interstratified. The strike along the Same-gawa in the central part is N. N. W., the dip being steeply to E.

Kitakami Mountains.—The rocks are mainly of the Middle and Upper Chichibu Series. The Lower Series is developed only east of Kurosawajiri. The strike is W. S. W. in the South and N. N. W. in the north.

In the southern part of the Mountains in Rikuzen *Fusulina* is found in the limestones of Maiya, Tsukitate, etc.; while the limestone of Kobama, Naburi, Maiya, Tsukitate, etc. and the calcareous sandy claystate, alternating with limestone, of Kobama and Mitobe, have yielded pygidia of *Phillipsia*-like *Trilobites*, *Spirifer*, *Rynchonella*, *Productus ?*, *Euomphalus*, crinoids, bivalves, gasteropods, bryozoans, *Cyathophyllum*, *Beaumontia* and *Serpula*. At Nemari near Maiya pygidia of *Phillipsia*-like *Trilobites*, *Fenestella*, *Rynchonella*, *Productus ?*, *Orthis ?*, and crinoids have been found in the clayslate overlying the *Fusulina* limestone. In Yakejima near Kobama, *Lyttonia*, a brachiopod also found at Tsukitate, together with *Fenestella*, crinoids, *Spirifer glabra* (?) and other brachiopods have been found in a calcareous sandy clayslate.

Mutsu Province.—The Palæozic outcrops in small areas in the small peninsula of Kominato, in Shimokita Peninsula and near Kotomari in Tsugaru Peninsula. The rocks consist chiefly of quartzite and hornstone with limestone. The strike is E. N. E.

Hokkaidō.—The continuation of the Palæozoic formation seen in Mutsu outcrops in Oshima and Shiribeshi. The strike is N. 80° E. in the eastern part of Hakodate, and is rather complicated in the peninsula of Matsumae, but the prevailing strike is N. E. The Palæozoic strata containing thick limestone, in the environs of Toyonaga in Shiribeshi, have also the N. E. strike. By far the greater portion of the Palæozoic rocks of the Ezo Mountains are of the Middle and Upper Chichibu Series. They are sandstone and clayslate with subordinate layers of limestone, schalstein, quartzite, hornstone, and adinole slate. The Lower Chichibu Series is found on the western flank of the Ezo Mountains along the granite-zone of the Hitaka Range. Pyroxenite with limestone is found at Kamuikotan in Ishikari and pyroxenite is also found in the valleys of many branches, of the Teshio-gawa. The small Palæozoic area isolated on the lower course of the Mitsuishi-gawa consists also of pyroxenite. The general strike in the Mountains is N. N. W.

Taiwan.—No Palæozoic fossils are yet known in the Island. Thick clayslate occurs on both sides of the middle range. On the western side a thick limestone intervenes between it and the crystalline schists, and gradual transitions are observed between them. No abrupt change, lithological or tectonic, has been found in the clayslate, or between it and the Tertiary strata. On the eastern side the clayslate directly borders with the schists. The strike generally coincides with the direction of the Mountain Range. On the eastern side the strata dip eastward; on the western, they form an anticline and a syncline near the water-shed, and the dip is steeper in the eastern portion, it being from 70° to 80° near the Crystalline Schists of the east, while it is from 30° to 40° near the boundary of the Tertiary on the west.

The upper part of the formation is clayslate with thin layers of sandstone; this might represent the Mesozoic Group. The lower part consists of phyllite, quartzite, metamorphosed sandstone and crystalline limestone. The lowest portion resembles the Crystalline Schists. Thick beds of crystalline limestone occur in the Palæozoic formation as well as in the Crystalline Schists. They stretch from the south of Suō in the north to the south of the Hinan-Taikei, where they become thinner and disappear near the upper Tamari-kei.

CHAPTER VI.

MESOZOIC GROUP.

The Mesozoic Group of Japan comprises the three great divisions, each characterized by typical fossils. Compared with the Palæozoic formation, the extent of the Mesozoic is limited, as the building of the ground-structure of the Japanese Islands had been already completed when the deposition ot the Mesozoic took place.

The Triassic System occupies small areas, both in the inner and outer zones of Japan, namely in the southern part of the Kitakami Mountains, the Sakawa Basin in Tosa, Kuriki in Higo, Nariwa in Bitchū, and Yamanoi in Nagato.

The Jurassic System occurs also in the inner and outer zones. The Jurassic strata in the southern part of the Kitakami Mountains in the outer zone are marine deposits with ammonites, and those in Kaga, Echizen, Etchū, Hida, in the inner zone, are brackish-water deposits with plant remains. As an exceptional case ammonites are found in Nishinakayama, in Nagato, in the inner zone.

The Cretaceous System is exposed in large areas in the outer zone and only in patches in the inner zone. In Northern Japan it appears on the western flank of the Ezo Mountains, on the eastern side of the Abukuma Mountains and in the Sanchū *Graben* in the Kwantō Mountains. In Southern Japan it stretches westward from Shima Province to Amakusa Island in Kyūshū, through the southern part of Kii and Awaji, Shikoku and the northern part of the Kyūshū Mountain Range. It also appears in Izumo.

The rocks, which are barren of fossils but seem to belong to the Mesozoic from lithological and other considerations, are grouped as Mesozoic of unknown epochs.

I. TRIASSIC SYSTEM.

E. von Mojsisovics[1] has shown that the Trias of Japan consists of marine deposits belonging to the Arcto-Pacific Triassic Ocean. The Ammonites and *Pseudomonotis* of the Japanese Trias are considered closely allied to those of the Californian Trias. The correlation of the Japanese Trias with the Californian and other corresponding series is as follows:

Series.	Stage.	Substage.	Japan.	Australia.	Nevada and California.
Bajuvavic.	Rhaetic	Rhaetic.	*Dictyophyllum.*		
	Juvavic.	Sevatic.	*Pseudomonotis ochotica* Bed.	*Pseudomonotis ochotica* Bed.	Swearinger Slates with *Rhabdoceras Russelli*, and *Pseudomonotis sub-circularis.*
		Alaunic.			
		Lacic.			
Tyrolic.	Karnic.	Tuvalic.			Hosselkus Limestone with *Tropites.*
		Julic.			Homfraji beds.
		Cordevolic.			Star Peak group.
	Noric.	Longobardic.			
		Fassanic.	*Ceratites japonicus* Bed.		*Anolcites americanus* Bed.

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[1] E. v Mojsisovics, Ueber einige japanische Triasfossilen, Beiträge zur Palæontologie Oesterreich-Ungarns und des Orients, Bd. VII, 1888.

E. v. Mojsisovics, Cephalopoden-faunen der oberen Trias des Himalaya etc., Verh. d. k. k. geol. Reichsanstalt, 1896, Nr. 13.

Series.	Stage.	Substage.	Japan.	Australia.	Nevada and California.
Dinaric.	Anisic.	Bosnic.			
		Balatonic.			
	Hydaspic.	Hydaspic.			
Skythic.	Yakutic.	Yakutic.			
	Brahmanic.	Gandanic.			
		Gangetic.			

Trias of the Kitakami Mountains.

The Trias of the southern part of the Kitakami Mountains contains two fossiliferous beds, namely the *Ceratites* Bed and the *Pseudomonotis* Bed.

The *Ceratites* Bed consists of sandstone and clayslate and is found at Inai, Ōuri, Yanagiza, Okatsuhama, Shizugawa, etc. The strike of the bed is generally N. or N.N.E. and the dip E. on the western and W. on the eastern side of the Mountains; the bed forms a large syncline on which still younger formations rest.

The fossils found are:—

Ceratites japonicus E. v. Mojs
„ *Haradai* E. v. Mojs
Danubites Naumanni E. v. Mojs.
Arpadites (*Clinites*) *Naumanni* E. v. Mojs.
Anorcites Gottschei E. v. Mojs.

Japonites planiplicatus E. v. Mojs. was found on the sea-bottom off Okatsuhama.

The *Pseudomonotis* Bed consists also of sandstone and clayslate and is found at Isadomae and Tsuya on the eastern side of the Mountains. Its strike is N. N. E. The fossils found are *Pseudomonotis ochotica* (Keyserl.) Teller, besides stems of crinoids and gasteropods.

Trias of the Sakawa Basin.

The Sakawa Basin is a hilly region in the high Palæozoic mountains and lies 10 *ri* west of Kōchi. The Triassic fossils found there are:—

Pseudomonotis ochotica Teller.
Daonella sakawana E. v. Mojs.
„ *Kotoi* E. v. Mojs.
Ceratites sakawanus E. v. Mojs.

besides *Terebratula*, *Avicula*, *Pecten*, *Lima*, *Exogyra*, etc. Mojsisovics compared *C. sakawanus* to *Tibetites*, which is found in India.

Pseudomonotis Bed of Kuriki, Higo.

The Bed consists of fine-grained, dark gray sandstone and shale, and contains *Pseudomonotis ochotica.*

Trias of Nariwa.

The Triassic rocks of Nariwa in Bitchū consist of sandstone in the lower and shale with anthracite in the upper part. The strike of the strata is N. W. with a gentle dip to S. W. The upper horizon gives the following plant fossils:—

Podozamites Reinii Geyler.
„ *lanceolatus Eichwaldi ?* Hr.
„ sp.
Nilssonia sp.
Macrotæniopteris ?

Porphyrite tuff and a thick limestone lie on the plant horizon.

The synclinal strata in the south of Jitō, south of Nariwa yield *Pseudomonotis.*

Rhætic Formation of Yamanoi.

The Rhætic Formation stretches eastward from Habu to Asa in the province of Nagato. It is covered by the Tertiary in the south and by the Lias in the north. It consists of a thick series of shale and sandstone with intercalated anthracite seams. The general strike is E.—W. and dip mostly N. 60°. Plant fossils found at Yamanoi are:—

Dictyophyllum cf. *acutilobum* BRAUN.
„ *japonicum* YOK.
„ *Kochibei* YOK.
Podozamites lanceolatus, var. *genuina*, var. *minor*, var. *Eichwaldi*, var. *intermedia*.
Spiropteris sp.
Pinus sp.
Nilssonia cf. *ozoana* YOK.
Baiera cf. *paucipartela* NATH.
Asplenium Rœsserti PRESTL.

Dictyophyllum acutilobum is found in the Rhætic of Europe, Persia, and Tongking, and *Baiera paucipartela* is found in Sweden.

II. JURASSIC SYSTEM.

The Jurassic System has been recognized in small detached areas consisting both of marine deposits, as in Nagato and Rikuzen, and of brackish-water deposits, as in Echizen, Kaga, Etchū, Echigo, and in the region on the boundary of Mino and Hida. The schalstein which is widely spread in Chūgoku and the northern part of Kyūshū, and which is mapped as Mesozoic of an unknown epoch, resembles in lithological character the Liassic schalstein of Nagato; but as yet we have no palæontological data for the correlation of the two formations.

The following series are distinguished in the Jurassic System :—

1. Inkstone Series of Nagato.
2. Shizugawa Series.
3. Tetori Series.

1. *Ink-stone Series of Nagato.*

The Jurassic rocks in Nagato are composed of

Upper—Shale, sandstone, conglomerate, schalstein, breccia, and crystalline limestone.
Lower—Shale, sandstone, and conglomerate.

Anthracite is intercalated in the strata both in the lower and the upper horizons. There are two varieties of schalstein, violet and green; the violet variety furnishes the best ink-stones (*Suzuri*) in Japan. The dip of the strata is N. in the eastern and N. W. in the south-western part of Nagato.

K. Inouye has discovered ammonites in sandy shale of the lower horizon in Nishinakayama; they are as follows :—

Harpoceras cf. *radians* SCHL.
„ n. sp. allied to *H. radians.*
„ cf. *Levisoni.*
„ n. sp. allied to *H. normanianus* D'ORB.
„ n. sp. „ „ *H. bifrons.*
„ cf. *atriatulum* SOW.
„ cf. *aalense.*
„ cf. *costula* OPP.
„ n. sp. allied to *H. cadomensis.*
„ n. sp. „ „ *H. Lythense* and *H. Eseri*
„ n. sp. „ „ *H. exarætum* and *H. opalinum.*
„ n. sp. „ „ *H. Murchisonæ.*
„ n. sp. „ „ *H. complanatus.*

Perisphinctes n. sp. allied to *Stephanoceras commune.*
„ n. sp. „ „ *St. annulatum.*
„ n. sp. „ „ *St. bifulcatum.*
„ n. sp. „ „ *P. Bollensis.*
Arietites.
Lytoceras ?

The ammonite fauna, when compared with European species, are referable to the Black Jura or Lias, especially to the upper horizon of the same.

Inouye has also discovered in the south of Isa *Asplenium*, *Podozamites lanceolatus* (*?*), *Nilssonia*, *Pinus*, etc. in shale interstratifying with sandstone.

2. *Shizugawa Series.*

The Jurassic of the Kitakami Mountains rests directly upon the synclinal fold of the Trias. According to K. Jimbō it is divided into two groups, upper and lower. The lower group consists mainly of clayslate and contains at Nakano and Niranohama marine fossils, such as *Trigonia of the Costatæ Group*, *Cyrena*, *Gervillia*, *Perna*, *Exogyra*, etc.

The *Trigonia* bed of the lower group seems to overlie the Trias conformably, but the stratigraphical relation between the bed and the Ammonite bed of the upper group is not distinct, as the two beds are separated by a fault.

The lower part of the upper group consists of clayslate and sandstone which are devoid of fossils while the upper consists of shale with ammonites, *Trigonia V-costata* Lyc., *Belemnites*, etc. Of ammonites, T. Iki has described the following species :—

Harpoceras cf. *aalense* Fieten.
Aegoceras cf. *angulatus* Schlot.
Lytoceras sp.

The above-mentioned species are allied to those found in the Black Jura in Europe and also in Nagato. The *Trigonia*

Bed, which represents the lower horizon in Kitakami, has not yet been found in Nagato.

3. *Titon Series.*

The Jurassic rocks that are exposed in detached areas over Echizen, Etchū, Echigo, Kaga, Mino, and Hida consist of brackish-water deposits with characteristic plant fossils.

The plant remains of the Upper Tetorigawa in Kaga were first collected by J. J. Rein, and since then abundant species have been obtained from that region. Forty-four species were determined by M. Yokoyama[1] who proposed the name of the Tetori Series to distinguish the plant-bearing formation of the Hokuriku region from the other plant beds that occur mostly in the outer portions of Japan.

The rocks consist of conglomerate in the lower part and of sandstone and shale in the upper, with a general dip to N. W.

The following table shows the fossils that were described by Yokoyama, together with their localities.

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[1] Jurassic Plants from Kaga, Hida and Echizen. Journ. Col. Science, vol. III. 1889.

Tabular View of the Jurassic Plants of Kaga, Hida and Echizen (*Yokoyama.*)

No.	NAMES.	KAGA.			ECHIZEN.		HIDA.		OCCURRENCE OF IDENTICAL OR ALLIED SPECIES IN OTHER COUNTRIES.
		Shimamura.	Yanagidani.	Ozō.	Hakogase.	Tanimura.	Okamigō.	Ushimaru.	
	CLASS I. CRYPTOGAMAE.								
	ORDER I. FILICACEAE.								
	Fam. I. Polypodiaceae.								
1.	Thyrsopteris Murrayana Brgt...	–	–	–	–	–	+	–	Siberia, Yorkshire.
2.	„ prisca Eichw.......	+	–	–	–	–	–	–	Siberia, Russia.
3.	„ kagensis nov. sp...	+	–	–	–	+	–	–	
4.	Dicksonia gracilis Hr....	+	–	–	–	–	+	–	Siberia,
5.	„ acutiloba Hr. var. ...	+	–	–	–	–	–	–	Siberia,
6.	„ cfr. Glehniana Hr....	–	–	–	+	–	–	–	Siberia, Yorkshire (?)
7.	„ nephrocarpa Bunb...	+	–	–	–	–	–	–	Siberia, Yorkshire.
8.	Onychiopsis elongata Geyl.......	+	+	+	+	+	+	–	
9.	Adiantites Heerianus nov. sp...	+	–	–	–	–	–	–	
10.	„ Kochibeanus nov. sp.	+	–	–	–	–	–	–	
11.	„ lanceus nov. sp.	–	–	–	+	–	–	–	
12.	Asplenium whitbiense Brgt. ...	+	–	+	–	–	–	–	Siberia, China, Mongolia, India, (Jabalpur and Kach), Yorkshire, Turkestan, Rajmahal.
13.	„ argutulum Hr.........	+	–	+	+	–	+	–	Siberia, Mongolia, Russia, Yorkshire.
14.	„ distans Hr.............	+	–	+	+	–	–	+	Siberia, Yorkshire.
	Fam. 2. Sphenopterideae.								
15.	Sphenopteris sp.	–	–	–	+	–	–	–	*Sphenopteris Williamsonis Brgt.* of Oolite and *S. Mantelli Brgt.* of Wealden.
	Fam. 3. Peccpterideae.								
16.	Pecopteris exilis Phill............	+	–	–	–	–	–	–	Spitzbergen, Yorkshire.
17.	„ Saportana Hr.........	+	–	–	–	–	–	–	Spitzbergen.
	Fam. 4. Taeniopterideae.								
18.	Taeniopteris (?)	–	–	+	–	–	–	–	
19.	Macrotaeniopteris cfr. Richthofeni Schenk	+	–	–	–	–	–	–	China.
	ORDER 2. RHIZOCARPEAE.								
	Fam. I. Salviniaceae.								
20.	Sagenopteris sp.	–	–	+	–	–	–	–	*Sagenopteris rhoifolia Presl.* of Liassic and Rhaetic of Europe.
	ORDER 3. CALAMARIEAE.								
	Fam. I. Equisetaceae.								
21.	Equisetum ushimarense nov. sp.	–	–	–	–	–	–	+	*Equisetum Buchardti Schimp.* of Wealden.
22.	„ sp.	–	–	–	–	–	+	–	

No.	Names.	Kaga.			Echizen.		Hida.		Occurrence of identical or allied Species in other countries.
		Shimamura.	Yanagidani.	Ozō.	Hakogase.	Tanimura.	Okamigō.	Ushimaru.	
	CLASS 2. PHANEROGAMEÆ.								
	SUBCL. GYMNOSPERMAE.								
	ORDER. I. CYCADEACEAE.								
	Fam. I. Zamieae.								
23.	Anomozamites sp.	+	−	−	−	−	−	−	
24.	Nilssonia orientalis Hr.	−	−	−	+	−	−	−	Siberia, Yorkshire.
25.	„ ozoana nov. sp.	−	−	+	−	−	−	−	
26.	„ nipponensis nov. sp.	+	−	−	−	−	+	−	*Nilssonia acuminata Göp.* of Rhaetic.
27.	„ (?)	−	−	+	−	−	−	−	
28.	Dioonites Kotoei nov. sp.	+	−	−	−	+	−	−	*Dioonites Brongniarti Schenk* of Wealden.
29.	Zamites parvifolius Geyl.	+	−	−	−	−	−	−	
30.	Podozamites lanceolatus Lind.	+	−	−	+	+	+	+	Siberia, China, Spitzbergen, Yorkshire.
	var. b. intermedia Hr.	+	−	−	−	−	+	−	Siberia, China, Mongolia.
	var. c. Eichwaldi Hr.	+	−	−	−	+	+	+	Siberia, China, Spitzbergen Russia.
	var. d. minor Hr.	+	−	−	−	−	−	−	Siberia.
	var. e. latifolia Hr.	+	−	−	−	−	−	−	Siberia, China, Mongolia.
	var. f. brevis Schenk.	−	−	−	−	−	+	−	China.
	var. g. .	+	−	−	−	−	−	−	
31.	Podozamites tenuistriatus Geyl.	+	−	−	−	−	+	−	
32.	„ Reinii Geyl.	+	+	+	−	+	+	−	
33.	„ sp.	−	−	−	−	−	+	−	
34.	„ sp.	+	−	−	−	−	−	−	
35.	Dictyozamites indicus Fstm. var. distans	−	−	+	−	−	−	+	*Dictyozamites indicus Fstm.* Rajmahal.
36.	„ grossinervis nov. sp	+	−	−	−	−	−	−	
	Fam. 2. Cycadeae.								
37.	Cycadeospermum japonicum Geyl.	+	−	−	−	−	−	−	
	ORDER 2. CONIFERAE.								
	Fam. I. Taxaceae.								
38.	Ginkgodium Nathorsti nov. sp.	+	+	−	−	−	+	−	
39.	Ginkgo digitata Brgt.	−	−	−	−	−	+	−	Siberia, Spitzbergen, Yorkshire.
40.	„ cfr. lepida	−	−	−	+	−	−	−	Siberia.
41.	„ Sibirica Hr.	+	−	−	−	−	−	−	Siberia.
42.	Czekanowskia rigida Hr. (?)	−	−	+	−	−	+	−	Siberia, China, Russia, Yorkshire, Rhaetic of Sweden.
43.	Taxites sp.	−	−	+	−	−	+	−	*Taxites brevifolius Nath.* of Yorkshire.
44.	„ sp.	+	−	−	−	−	−	−	
	Fam. 2. Abietaceae.								
45.	Pinus cfr. prodromus Hr.	+	−	−	−	+	−	−	Siberia, Spitzbergen.
46.	„ Nordenskjoldi Hr.	+	−	−	−	−	−	−	Siberia, Spitzbergen, Russia, Andō? Nancy?
47.	Palissya sp.	+	−	−	−	−	−	−	*Palissya jabalpurensis Fstm*, Jabalpur.
	INCERTAE SEDIS.								
48.	Vallisneriites jurassicus Hr. (?)	+	−	+	−	−	−	−	Siberia.
49.	Carpolithes ginkgoides nov. sp.	−	−	+	−	−	−	−	

Of these forty-nine species, nineteen are found in the Brown Jura of Siberia, Spitzbergen, and Yorkshire. The lower horizon of the plant-bearing strata contains fresh-water shells, of which *Cyrena* forms an important part.

Shimamura. This place is situated on the upper Tetorigawa, 15 *ri* above the river mouth. Abundant fossils are here found imbedded in black and yellowish gray sandy shale, dipping 20° S.E. The lower part contains shell remains, which are too imperfect for determination.

Ozō, 3 *ri* N.E. of Shimamura. Plant-bearing black sandy shale, 1 or 2 meters in thickness, covers sandstone and conglomerate which lie on gneiss and form the base of the Jurassic. They dip 15°—20° N.

Okami, Hida, is situated 2 *ri* W. of Okami-honmura on the Shira-kawa. Plant remains are here imbedded in a black shale, interstratified with sandstone that has a strike of S. 30° E. and dip of S.S. W. 2°. The strata also yield the remains of *Ostracoda.*

Ushimaru, S. of Okami. The fossiliferous strata dip 15° S.W. and their stratigraphical succession as follows:—

1. Conglomerate.
2. Sandstone.
3. Gray shale (plant-bed).
4. Black shale (with shells).
5. Granitic Gneiss.

Hakogase, Echizen. This place is on the upper Kuzuryūgawa, 10 *ri* S.E. of Ōno. The strike of the strata is generally N. W., forming a syncline. Well preserved plant fossils are found in dark gray sandy shale.

Kanidera, Etchū, near Arimine in the southern part of the province, not far from the boundary of Hida. The rocks consist of the lower conglomerate with pebbles of granite and gneiss and of the upper sandstone and shale.

Region near the boundary of Etchū and Echigo. The

Mesozoic strata that outcrop in small patches in this region consist mainly of conglomerate in the lower, sandstone and shale in the middle, and of shale in the upper part. The strike is N.W. *Cyrena* is found at Hashidate and Terayama; the latter locality yields also plants in the upper shale.

Region near the boundary of Tamba and Tango. Rocks at Yuragawa and Maezuru yield ill-preserved plant remains, which resemble those from the Jurassic above mentioned. *Apiocrinus* is found in sandstone in the southwestern part.

III. CRETACEOUS SYSTEM.

Of all Mesozoic rocks the Cretaceous System has the widest distribution in Japan. It is grouped as follows:—

1. Torinosu Limestone.
2. Ryōseki Series.
3. Izumi Sandstone Series.
4. Cretaceous of Hokkaidō.
5. Shinji Series.
6. Cretaceous of Southern Shikoku and Kii.
7.(?)Misaka Series.
8.(?)Mikura Series.

1. *Torinosu Limestone.*

A dark bituminous, sometimes oolitic, limestone occurs in the series of sandstone and shale of the lower Cretaceous developed on the Pacific side of Honshū and Shikoku. As the limestone contains characteristic fossils and many of them were first collected at Torinosu near Sakawa in Tosa, the name of Torinosu Limestone is used to designate that particular bed.

Torinosu Limestone contains a rich fauna consisting of foraminifera, corals, bryozoa, echinoids, bivalves, and gasteropods.

In Torinosu Limestone in the environs of Sakawa, M. Neumayr and M. Yokoyama,[1] have recognized the following species:—

Cyclammina litus YOK.
Textularia cf. *cordiformis* SCHW.
Pulvinulina (?) sp.
Chætetopsis crinita NEUM.
Convexastræa (?) *orientalis* NEUM.
Cidaris cf. *glandifera* GOLDF.
Hemicidaris cf. *crenularis* AG.
Terebratula bisuffurcinata ZIET.
Nerinea cf. *Visurgis* RÖMER.

E. Sagawa has found a limestone full of shells closely resembling *Alectryonia amor* D'ORB. at Ogawa in the west of Sakawa, and

Thamnastræa, *Isastræa*, *Calamophyllia*,
Montlivaultia (?), *Chætetopsis crinita* NEUM.
Cidaris cf. *glandifera* GOLDF.
Nerinea cf. *dilatata* D'ORB.

in the limestone of Shiraishigawa, 40 km. west of Sakawa, where the layers of limestone interstratify with plant beds, containing *Pecopteris Browniana*, *Zamiophyllum Buchianum*, *Nilssonia Schaumburgensis ?*, *Podozamites*.

T. Iki has found, in the Monobegawa valley in the east of Kōchi in Tosa, *Chætetopsis crinita*, *Thamnastræa*, *Latimeandra*, *Nodosaria*, *Belemnites*, *Nerinea*, *and Chemnitzia*.

Cidaris cf. *glandifera* and *Chætetopsis crinita* are very common fossils found in the limestone; they are found, among other species, at Itsukaichi in Musashi, and the latter is found in Sōma district on the east side of the Abukuma Mountains.

The Cretaceous rocks in Sōma district in Iwaki contain two layers of fossiliferous oolitic limestone which are overlaid conformably by a plant bed of the Ryōseki series. A tooth of *Strophodus* has been found in the limestone.

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[1] Naumann u. Neumayr, Geologie u. Paläontologie von Japan. Denksch. d. Meth. Naturw. Cl. d. Kais. Akad. d. Wiss. Bd. DLVII. 1890.

Torinosu Limestone was considered as upper Jurassic by M. Neumayr, his data being a few fossils correlated with European species. But field observation shows that the limestone is found in many cases in the plant-bearing series, and it seems impossible to assign to it a chronological position distinct from the so-called Ryōseki Series containing Neocomian plants, which has also a very close relation to the Cretaceous *Trigonia* sandstone; and hence the limestone is included in the Cretaceous on the ground of the accompanying fossiliferous beds, which have since been better studied and have thus become more trustworthy as guides in the determination of age.

2. *Ryōseki Series.*

The Ryōseki Series has a comparatively wide distribution, appearing in the eastern part of the Kitakami Mountains, the north-eastern part of the Abukuma Mountains, the Sanchū *Graben* of the Kwantō Mountains, and in the provinces of Kii, Awa, and Tosa. The rocks consist~~s~~ of conglomerate, sandstone and shale. Generally speaking, a *Cyrena* bed occurs in the lower horizon of the series, a plant bed is found a little higher, and a *Trigonia* sandstone forms the uppermost part.

Plant remains are the characteristic fossils of the Series. According to M. Yokoyama[1] they show a close relation to the Wealden of Europe and Potomac Formation of America and the Ryōseki Series represents the whole Neocomian of the Lower Cretaceous.

Plant fossils with their localities are given in the annexed table.

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[1] Mesozoic Plants from Kōzuke. Kii, Awa, and Tosa. Journ. Col. Sci. Imp. Univ., vol. VII, 1895.

Table of Distribution of

	Kō-zuke.	Kii.	Awa.			
	Kagahara.	Yuasa.	Sakamoto.	Fujikawa.	Tanno.	Mitani.
Filices.						
Thyrsopteris sp.	...	...	...	+		
Dicksonia tosana.	...	...	...	...	...	...
Dicksoniopteris Naumanni.	...	...	...	...	...	...
Onychiopsis elongata.	+	+	...	+	...	+
„ elegans.	...	...	...	...	...	...
Adiantites yuasensis.	...	+	...	...	...	...
Pteris (?) sp.	+	?	...	...	...	...
Sphenopteris tenuicula.	+	+	...	...	...	...
Pecopteris Browniana.	...	...	...	+	...	...
„ Geyleriana.	...	+	...	+	...	...
„ cf. virginiensis.	...	...	...	+	?	...
Chladophlebis Nathorsti.	...	+	...	...	—	?
Lycopodiacae.						
Licopodites sp.	...	...	...	...	...	...
Cycadeacae.						
Podozamites sp.	...	...	...	...	...	...
„ lanceolatus var. minor.	...	...	...	...	+	...
„ „ „ latifolia.	...	...	...	...	...	...
„ pusillus.	+	...	...	...	...	...
Zamiophyllum Buchianum.	+	+	+	...	+	...
„ „ var. angustifolia.	...	+	...	...	...	...
„ Naumanni.	...	+	...	...	...	...
Glossozamites parvifolius.	...	+				
Nilssonia Johnstrupi.	...	...	...	...	...	...
„ schaumburgensis.	+	+	...	...	...	+
„ pterophylloides.	...	+	...	...	...	...
Ptilophyllum cf. cutchense.	...	...	...	...	...	...
Coniferae.						
Cyparissidium (?) japonicum.	+	...	...	+	+	...
Torreya venusta.	...	+	...	...	...	...

Plants of the Ryōseki Series.

	Tosa (Ryōseki district.)								Tosa.				
Kataji.	Ishiseki.	Tōgodani.	Yakyō.	Ueno.	Torikubi.	Ōtani.	Haginotani.	Kaisekiyama.	Yoshida-yashiki.	Monobegawa.	Shiraishigawa.	Formations in which species of the Ryōseki Series are found.
...	...	+	...	...	...	...	...	...	...	...	...	
+	+	...	...	...	...	...	...	...	...	...	...	
+	+	+	+	+	...	+	+	+	...	+	...	Middle Jurassic of Kaga, Hida, etc.
...	...	...	...	...	...	...	...	+	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	+	...	...	...	...	+	...	+	...	
+	...	+	...	...	...	...	?	+	+	?	+	Wealden of Europe. Potomac of America.
+	...	...	...	...	+	...	...	+	...	+	...	
...	...	...	...	...	...	...	...	...	...	...	...	Potomac of America.
+	+	+	...	+	...	...	...	+	...	+	...	
...	...	...	...	+	...	...	...	...	...	...	...	
+	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	Rhaetic, Jurassic and Cretaceous of Europe.
+	...	...	...	...	...	...	...	...	...	...	...	Middle Jurassic of Kaga etc.
...	...	...	...	...	...	...	...	...	...	...	...	Cenomanian of Bohemia.
+	+	+	...	+	+	+	...	+	...	+	+	Urgonian of Europe, Potomac of America.
+	...	...	...	...	...	...	...	+	...	...	...	Potomac of America.
+	+	+	...	...	...	...	...	+	...	+	...	
...	...	...	...	...	...	...	...	...	...	...	...	
+	...	+	...	...	...	...	...	...	...	...	...	Kome beds of Greenland.
+	...	+	...	...	...	...	...	...	...	+	...	Wealden of Europe.
+	+	...	...	...	...	...	...	...	...	?	...	
...	...	...	...	...	...	...	...	...	...	...	+	Kajmahal of India.
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	

Ryōseki, Tosa, is a low hilly tract N.W. of Kōchi. The lower part of the strata consists of black shale which is overlaid by a thick conglomerate. The plant-bed lies on the conglomerate, and it is directly overlaid by sandstone with *Trigonia pocilliformis.*

Monobe-gawa Basin, Tosa. The lower part consists of a thick series of sandstone and shale containing marl; they yield two species of *Trigonia*, *Avicula*, Belemnites, and Ammonites (*Stephanoceratidæ*). The overlying conglomerate yields

Pecopteris Geyleriana.
„ sp.
Nilssonia orientalis.
Podozamites sp.
Sphenopteris tenuicula.

Still higher lie a *Cyrena* bed and a plant bed, which latter yields

Zamiophyllum Buchianum.
„ *Naumanni.*
Pecopteris sp.

Sakawa, Tosa. Plant fossils are imbedded in dark sandy shale at Yoshida-yashiki and yellow shale at Kaiseki-yama; the latter locality produces besides the well preserved plant fossils of the Ryōseki Series, *Exogyra*, *Avicula*, *Nucula*, *Isocardia*, *Melania*, *Natica*, *Opis*, etc., very near the plant horizon.

Katsura-gawa Valley, Awa. At several places in the basin of the Katsura-gawa, plant fossils are found. *Trigonia* sandstone overlies the plant bed, and the two beds are sometimes so closely related that it is difficult to distinguish the boundary between them. *Cyrena* occurs at Takegatani.

Yuasa, Kii, 7 *ri* S. of Wakayama. The rocks exposed on the north-eastern sea-coast consist of conglomerate, sands stone, and shale dipping steeply to N. The sandstone contain-plant fossils and the shale directly below it yields *Cyrena*, *Melania*, *Ostrea*, etc.

Kagahara, Kōzuke. This locality is in the so-called Sanchū *Graben* in the Chichibu region. *Cyrena* and plant fossils are imbedded in the lower part of the strata exposed in the Hachimanzawa.

Ōshima, Rikuzen. The rocks here consist of whitish coarse-grained or grayish fine-grained sandstone, clayslate, and sandy shale. They form two small anticlines with the general strike of N. 15° W. They contain according to T. Wakimizu

Asplenium Roesserti HR.
Pecopteris Geyleriana NATH.
„ *exilis* PHILLIPS.
„ *Browniana* DUNK.
„ cf. *Dunkeri* SCHIMP.
Dicksonia acutiloba HR.
„ sp.

3. *Izumi Sandstone Series.*

The rocks of the series consist chiefly of bluish gray sandstone with subordinate layers of conglomerate and shale. The sandstone is the most widely used for building purposes in Japan and is commonly known as 'green stone.'

On the Pacific side, the Izumi Sandstone Series occupies detached areas in Rikuzen and in Awa and Tosa where it directly overlies the Ryōseki Series. On the inner side, it also forms a long chain stretching through the Izumi Range, Awaji, Sanuki, Iyo, Bungo, and the Islands of Amakusa. It also appears at Todai in Shinano, and in the Sanchū *Graben* in Kōzuke. By far the most characteristic fossil is *Trigonia pocilliformis* Yok., which is found in Higo, Awaji, Awa, Tosa, Kōzuke, Shinano (Todai), and Hokkaidō.

Other fossils are given below with their localities in Honshū, Shikoku, and Kyūshū.

Pravitoceras sigmoidale YABE.[1] Minato in Awaji.

Anisoceras awajiense YABE.[1] Minato.

Peroniceras amakusense YABE.[1] Amakusa.

Lytoceras tenuiliratum YABE.[1] Amakusa.

Anisoceras sp. (aff. *A. indicum* FORB.) Kagahara in Kōzuke.

Phylloceras sp. (aff. *Ph. Velledæ* MICH.) Kagahàra.

Hamites sp. Amakusa.

Helicoceras sp. (aff. *H. indicum.*) Koumi in Sanuki.

Inoceramus sp. Amakusa in Higo, Inukai in Bungo (south of Ōita), Minato and Tsukisa in Awaji.

Belemnites sp. Minato, Kagahara (Sanchū *Graben*).

Cucullæa cf. *striatella* MICH. Kagahara.

Avicula Haradæ YOK. Kagahara.

Capulus annulatus YOK. Kagahara.

Crassatella kagaharensis YOK. Kagahara.

Atectryonia cf. *carinata* LAM. Sakawa, Kagahara.

Trigonia Kikuchiana YOK. Sakawa, Katsuragawa, Ryōseki.

Trigonia rotundata YOK. Katsuragawa.

The fauna resembles a part of the rich fauna of the Cretaceous of Hokkaidō.

Beside these marine fauna, fossil plants such as, *Arundo, Populus* (*?*), *Salix, Quercus, Fagus, Platanus, Cinnamomum* have been found by Y. Kikuchi at Komatsu in Amakusa, and dicotyledonous plants by T. Kochibe at Hachimanzawa in the Sanchū *Graben*, *Coniferæ* including *Sequoia* by T. Nasa at Okuyama in Sanuki; and large fucoids are obtainable at Shōbutani in Sanuki and Aikuri in Awa.

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[1] H. Yabe: Notes on Three Upper Cret. Ammonites from Japan outside of Hokkaidō. Journ. Geol. Soc. Tokyo, vol. VIII, 1901.

In the Izumi Sandstone Series that spreads over Izumi, Kii, Awaji, and the northern part of Shikoku, conglomerate generally occurs in the lower horizons, sandstone with thin shale in the middle, and sandstone and shale in the upper. *Trigonia* is imbedded in a sandstone that alternates with conglomerate, at Chikusa in Awaji, and ammonites are found in the black shale at Minato of the same province. The strike of the rock is E. N. E. and dip S. S. E. 30°–40°.

The Izumi Sandstone Series exposed in southern Awa and Tosa occurs in much the same manner as that of Kagahara. It lies directly on the Ryōseki Series. It contains at Tanno in Awa, besides three *Trigoniæ*, imperfect fragments of an evolute and a spirally rolled Ammonite. Near Sakawa were found besides *Trigoniæ*, *Alectryonia*, *Scaphites*-like ammonites, etc. In the Monobe-gawa valley the three zones of sandstone, conglomerate, and shale are distinguished; *Trigoniæ* are found in the sandstone, and belemnites in the black shale of the upper horizon.

The Mesozoic west and south of Yatsushiro in Higo consists of sandstone and shale, sometimes with conglomerate. It is developed in a narrow trough in the Palæozoic extending N. E.—S. W., and branching into two in the northeast.

On the Amakusa Islands sandstone and shale predominate and the former is quarried at many places. Anthracitic coal, is found interbedded in the series; the formation of the authracitic coal is ascribed to the contact action of intrusive sheets and dykes of liparite which are found exposed in several places. The strike of the strata is about N. N. E. in coincidence with the direction of the main range, and they form an anticline and syncline. Besides the fossils mentioned in the preceding page *Inoceramus*, *Sphenotrochis*, *Cardita*, Terebratella, Trigonia, Astarte, *Pecten*, *Lucina*, *Ostrea*, *Pholadomya*, *Pleuromya*, etc. have been found in the sandstone at Sakase and Imata in the Shimo-jima and the shale at Himeura in the Kami-jima.

According to the observations of Harada and Ōtsuka, the Izumi Sandstone Series of the Sanchū *Graben* lies on the Ryōseki Series with no noticeable unconformability. The lowest of the series is *Trigonia* sandstone and a formation, consisting of shale, sandstone and conglomerate, and containing ammonites, lies on it, the upper portion is a thick fossilless series of dark green shale and sandstone.

In Ōshima in Rikuzen, T. Wakimizu found *Trigonia*, *Nerinea* and *Ostrea* in a tufaceous sandstone overlying tuff. A black shale with oolitic limestone and several layers of quartzite are found alternating with the sandstone.

Very recently *Trigonia* (resembling *T. longiloba* Jimbō from Hokkaidō), belemnites and ammonites were found at Kuwagasaki on the coast of Rikuchū.

4. *Cretaceous of Hokkaidō.*[1]

The Cretaceous of Hokkaidō occupies a comparatively wide area along the western flank of the Ezo Mountains and appears in small patches in Nemuro and Shikotan Island. The rocks consist of sandstone, shale and conglomerate. The shale often contains lenticular masses of marl which yield abundant forms of ammonites, some of which reach a gigantic size. The strike of the beds generally coincides with the trend of the Ezo Mountains, but is often disturbed.

The characters of the Cretaceous rocks differ greatly from those of the Palæozoic and a manifest unconformability exists between the two formations. But between the Cretaceous and the Tertiary no sharp line of demarcation can be drawn, as distinctions between the two either in lithological characters or modes of occurrence are not clearly defined.

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[1] M. Yokoyama: Versteinerungen aus der japanischen Kreide. Palæontographica, Bd., XXXVI, 1890.

K. Jimbō: Beiträge z. Kennt. d. Fauna d. Kreideformation von Hokkaidō. Palæont. Abh., N. F. Bd. II, Heft 3, 1894.

H. Yabe: Fossil Cephalopoda of the Cretaceous of Hokkaidō, 1901, (MS.)

In the regions of the Teshio-gawa, Ikushum-bets, Obirashi-bets, Urakawa, etc. some signs of unconformability can be observed between the Cretaceous and the Tertiary, but in the coal-field of Yubari the Tertiary plant-bed lies conformably on the Cretaceous.

According to H. Yabe the stratigraphical succession is as follows :—

1. Upper ammonites bed.—Shale rarely intercalating sandstone ; nodules of marl containing fossils abundant. The fossils described by Yokoyama and Jimbō were got mainly from these beds. In them the following three subdivisions are recognized :

   a. *Pachydiscus* bed.
   b. *Scaphites* bed.
   c. Upper *Acanthoceras* zone.

2. *Trigonia* sandstone.—Sandstone with shale and conglomerate. Three fossil horizons are found in it, namely :

   a. *Pectunculns* zone.
   b. *Thetis* zone.
   c. Lower *Acanthoceras* zone.

3. Lower ammonites bed.—Shale, with subordinate sandstone, containing lenticular limestone (exposed on the middle course of the Sorachi-gawa).

The correlation of the Cretaceous fossil beds of Hokkaidō with those of foreign countries is as follows.

<table>
<tr><th colspan="2">Hokkaidō.</th><th>Other Parts of Japan.</th><th colspan="2">South India.</th><th>Canada.</th><th>California.</th><th></th></tr>
<tr><td rowspan="3">Upper Ammonites Beds</td><td><i>Pachydiscus</i> Bed.</td><td rowspan="2">Ammonite bearing shale of Amakusa.</td><td colspan="2">Ariyalur Group and Valudayur beds.</td><td rowspan="2">Nanaimo Group of Vancouver.</td><td rowspan="2">Upper Chico Group.</td><td rowspan="2">Senonian.</td></tr>
<tr><td><i>Scaphites</i> Bed.</td><td rowspan="2">Trichinopoly Group.</td><td>Upper.</td></tr>
<tr><td>Upper <i>Acanth.</i> Zone.</td><td>?</td><td>Lower.</td><td rowspan="2"></td><td rowspan="4">Lower Chico Group.</td><td rowspan="2">Turonian.</td></tr>
<tr><td rowspan="3"><i>Trigonia</i> Sandstone.</td><td><i>Pectunculus</i> Zone.</td><td rowspan="3">Izumi Sandstone of Shikoku etc. (part ?) Cret. of Sanchū (part ?) Trigonia s.s. of Todai, Cret. of Ōshima &amp; Miyako.</td><td rowspan="3">Utatur Group.</td><td>Upper.</td></tr>
<tr><td><i>Thetis</i> Zone.</td><td>Middle</td><td rowspan="3">C. Horizon of Queen Charlotte Islands.
↓</td><td rowspan="2">Cenomanian.</td></tr>
<tr><td>Low. <i>Acanth.</i> Zone.</td><td>Lower.</td></tr>
<tr><td colspan="2">Low. Ammonite Bed.
↓
?</td><td>↓
?</td><td colspan="2"></td><td>Shasta.
↓</td><td></td></tr>
</table>

Ammonites are found in the provinces of Hidaka (near Urakawa), Ishikari (Yūbari), Kitami, Teshio, etc. The annexed table is the list of ammonites, known from the Cretaceous formation of Hokkaidō.

Fossils other than ammonites are not few. The following have been determined.

Plesiosaurus sp. (vertebra).
Lamna sp. (teeth).
Lamna sp. (teeth).
Eucorystes japonicus JIMBŌ.
Ananchytinarum sp.
Pentacrinus sp.
Margarita funiculata YOK.
Helcion cf. *gigantia* SCHMIDT.

Exogyra sp.
Pecten cf. *Garudanus* STOL.
Inoceramus Naumanni YOK.
„ *ezoensis* YOK.
„ *angulosus* JIMBŌ.
„ *incertus* JIMBŌ
„ *digitatus* MUNSTER.
Trigonia longiloba JIMBŌ.
„ cf. *pocilliformis* YOK.
„ *dubovalis* JIMBŌ.
„ sp.
Pectunculus sp.
Nucula picturata YOK.
Cucullæa cf. *sachalineneis* SCHMIDT.
Lucina cf. *fallax* FORBES.
Meekea sella GAB ?
Thetis cf. *affinis* WHITEAVES.
Solen sp.
Siliqua sp.
Rhynchonella cf. *plicatiloides* STOL.
„ sp.
Kingena japonica YABE.
Carysphyllia arcotensis STOL.
Orbitolina concava LAM.

5. *Shinji Series.*

Near Yumachi in Izumo a cast of *Phylloceras* was discovered in a formation which had been considered, from its lithological character, as the Tertiary. The Shinji Range which is separated from the above locality by Shinji Lake is composed of shale and sandstone which yield dicotyledonous leaves and *Cyrena* and are considered by S. Ōtsuka as Cretaceous. Though the relation between these two formations is not yet well known, it is highly probable that they are to be included in one series of formations, for which the name of the Shinji Series is proposed.

6. *Cretaceous of Southern Shikoku.*

Besides the above-described series, there are formations covering wide areas in the outer zone of Japan in Kii, Shikoku and Kyūshū which either yield scanty Cretaceous fossils or are devoid of characteristic fossils and are presumed to be Cretaceous chiefly from their lithological characters and modes of occurrence.

In the formation of southern Shikoku, K. Inouye has found an *Inoceramus* at Nara east of Uwajima in Iyo, and M. Yagi *Inoceramus* cf. *cripsii* at Kunimi in southern Tosa. Limestone in the series contains corals. It became clear from these fossils that the formation comprises the upper Cretaceous. The formation is seperated from the Cretaceous areas of Shiraishigawa, Sakawa, Ryōseki and Monobegawa, of the Ryōseki Series and Izumi Sandstone Series, by a range consisting of the rocks which contain thick hornstone and limestone and which are considered as Palæozoic; but in the east the boundary between the fossiliferous formation of the Katsuragawa basin in Awa and the fossilless formation in the south has not yet been defined.

7. *Misaka Series.*

A formation exposed in the environs of Fuji and the eastern flank of the Akaishi Range was distinguished as the Misaka Series by T. Suzuki. The rocks consist of predominating tuff, sandstone, conglomerate and shale with characteristic intrusions of older looking eruptives such as diorite, diabase, porphyrite, etc. As the rocks present an older aspect than prevalent Tertiary types and in some cases show unconformability with overlying Tertiary beds they have been doubtfully included in the Mesozoic. But the investigation of the Misaka Pass region shows that between the Tertiary on the banks of Lake Kawaguchi, yielding *Orbitoides* and *Lithothamnium*, and the Misaka Series on the north, no stratigraphical demarcation can be made out; hence the Misaka Series of this region at least may possibly be included in the Tertiary System.

8. *Mikura Series.*

The rocks on the Southern rim of the Akaiishi Range in Suruga and Tōtōmi were named the Mikura Series by K. Nakashima. The Mikura Series consists of sandstone and shale with intercalating silicious limestone and hornstone. Silicious limestone is exposed in three zones; it contains *Globigerina*, *Nodosaria*, *Discorbina* (?), *Dactylopora* (?). Recently B. Kotō discovered in the series *Lithothamnium*, a characteristic Tertiary fossil which was first found in the Tertiary of Sagara in southern Tōtōmi. With this evidence the stratigraphical position of at least a part of the Mikura Series seems no longer doubtful.

9. *Other doubtful Mesozoic Formations.*

The Mesozoic in Kii peninsula consists of sandstone and shale sometimes with impure limestone of a gray colour. The rocks at Tsugatani along the Kumano-gawa contain dicotyledonous plants and those of Arita near Kushiki contain imperfect shell remains. A water-worn fragment of an ammonite was picked up some year ago by D. Yamashita at Kurihara east of the Kumano-gawa.

The Mesozoic of the southern half of Kyūshū consists also of sandstone and shale which dip generally to N. W.

and are apparently overlaid by the Palæozoic. Recently T. Iki has found *Inoceramus* on Shimo-Koshiki-jima. Though the other wide area has yet yielded no fossils, it is without doubt the continuation of the Mesozoic formations in southern Shikoku.

On the Island of Taiwan, the formation consisting mainly of clayslate with thin layers of sandstone, which stretches along the western and eastern flank of the axial mountain range and forms apparently the transition member between the Palæozoic on one side and the Tertiary on the other, is mapped as Mesozoic, but no fossil evidence has yet been found.

On the Island of Amami-Ōshima which is coloured as Palæozoic, and on the Island of Tanegashima which is coloured as Tertiary there occur rocks that have close resemblence to the above mentioned Mesozoic of Kyūshū and Shikoku.

fossils lie intermingled in many cases and the tracing of definite boundaries between those two formations has been attempted only in a few cases. The only Eocene formation thus far discovered is the tuff forming the Ogasawara-jima (Bonin Islands), which yields the characteristic fossil of *Nummulites*.

Shell beds containing abundant forms are widely distributed in Japan. Their grouping and stratigraphical sequence are not yet established. Many of the fossil shells from diverse parts of Japan have been identified with living species described by Reeve, Adams, Sowerby, Gould, Lischke, Dunker, etc. Indeed the shells from the Tertiary or rather Cainozoic strata that have specific names belong mostly to living species. The hitherto specifically named fossil shells, with their important localities, are given in the subjoined table.

TABLE OF CAINOZOIC FOSSIL MOLLUSCA WITH THEIR DISTRIBUTION.

Only those with specific names and those found in the important fossil localities mentioned below, including places best known by the abundance of varieties of fossils are given in the table. The few species, not in the table, from other localities which have but narrow distribution are mentioned on p. 83. The other important fossil localities are given with their chief fossils in the local description of the Tertiary strata.

1. Environs of Tokyo, including Ōji, Tabata, Surugadai, Sekiguchi, and Shinagawa.——**2.** Environs of Yokohama: Yokohama, Kanagawa, Takigashira, and Naganuma.——**3.** Matsudo, Shusui, and Iwahashi, in Prov. Shimōsa.——**4.** Ninomiya, Koshiba, and Kamimiyata in Prov. Sagami.——**5.** Kunō-zan and Negoya in Prov. Suruga.——**6.** Hatazawa and Nagaisaku in Prov. Kazusa.——**7.** Furutani and Dainichi in Prov. Tōtōmi.——**8.** Togari and Tsukiyoshi in Prov. Mino.——**9.** Yagurasawa and Kawanishi in Prov. Sagami, and Oyama in Prov. Suruga ('Ashigara Tertiary').——**10.** Sukegawa, Ōse, and Isowara in Prov. Hitachi.——**11.** Niigishi, Takinai, and Ezurabana in Prov. Kii.——**12.** Ananai, Ioki, and Aki in Prov. Tosa.——**13.** Koe-shima in Prov. Awaji.——**14.** Environs of Kanazawa in Prov. Kaga.——**15.** Sawane in Prov. Sado (Sawane Tertiary).——**16.** Chichibu in Prov. Musashi.——**17.** Hokkaidō.

It may be noticed that many of the specific names of the Tertiary shells were first assigned by D. Brauns in his work, 'Geology of the Environs of Tokyo' 1881, which has since been used as an indispensable reference book for the determination of Tertiary shells; recently it became known from study of S. Yoshiwara that some of the specific names in the book are ill-applied or doubtful. In this table names given by Brauns are retained, and those that should be taken with reserve are indicated by an interrogation-mark.

GASTEROPODA.	1. Tōkyō.	2. Yokohama.	3. Shimōsa.	4. Sagami.	5. Kunō-zan.	6. Kazusa.	7. Tōtōmi.	8. Mino.	9. 'Ashigara T.'	10. Hitachi.	11. Kii.	12. Tosa.	13. Koe-shima.	14. Kanazawa.	15. Sawane.	16. Chichubu.	kkaidō.
Ancillaria albo-callosa Lischke. ...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	-
Argobuccinum oregonse Rof.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	-
Buccinum leucostoma Lischke.......	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	-
Buccinum undatum Linné............	...	×	...	...	...	...	...	...	...	×	...	...	...	...	...	...	-
Bulla acuminata Berg.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	-
?Bulla convoluta Broc.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	-
?Bulla cylindracea Pen.	×	...	...	...	...	...	...	...	...	...	...	×	...	×	×	...	-
Bulla Lajonkaireana Adams..........	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	-
Bulla truncata Adams.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	-
Calyptræa chinensis L.	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	-
Cancellaria Spengleriana Desh. ...	×	×	×	?	...	...	...	...	...	...	...	...	...	...	...	...	-

	1. Tōkyō.	2. Yokohama.	3. Shimōsa.	4. Sagami.	5. Kunō-zan.	6. Kazusa.	7. Tōtōmi.	8. Mino.	9. 'Ashigara T.'	10. Hitachi.	11. Kii.	12. Tosa.	13. Koe-shima.	14. Kanazawa.	15. Sawane.	16. Chichibu.	17. Hokkaidō.
?Cassis pila Lischke.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Cemoria noachina L.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
?Cerithiopsis rugosa Gould	×	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Chemnitzia elegantissima Mont.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chemnitzia scalaris Phil.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
?Columbella scripta Lam.	×	×	...	×	...	×	...	...	...	...	...	...	...	...	×	×	...
Crepidula aculeata Gmelin.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
?Crepidula fornicata Lam.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Dolium luteostomum Küster.	×	×	...	×	...	...	...	×	×	?	...	...	...	...	...	...	...
Drillia reciproca Gould.	×	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...
Eburna areolata Lam.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Eburna japonica Reeve	×	×	×	...	...	×	...	×	...	...	...	...	...	...	...	...	...
?Eulima subulata Don.	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ficula reticulata Lam.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fusus inconstans Lischke	×	×	...	...	...	...	...	×	...	...	...	...	...	...	×	...	...
?Fusus simplex Smith.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Globulus monilifer Lam.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Globulus superbus Gould	×	×	...	×	...	×	×	×	...	...	×	...	...	...	×	...	...
Haliolites gigantea Chemnitz.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Lampania multiformis Lischke.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lampania zonalis Lam.	×	×	...	...	...	×	×	...	...	...	×	...	...	...	...	...	...
Mangelia storiolata Phil.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Monoptygma eximium Lischke.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Monoptygma puncticulata Gould	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
?Monoptygma striatum Gray	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nassa japonica Adams.	×	×	×	×	...	...	?	...	...	...	...	...	...	×	...	...	...
Nassa livescens Phil.	×	×	×	×	×	...	...	...	...	...	...	...	...	...	...	×	...
Natica janthostoma Desh. (N. clausa)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Natica Lamarckiana Recluz. (N. ampla)	×	×	×	×	×	×	×	×	...	×	...	...	...	...	...	...	...
Natica piriformis Recl.	...	...	...	...	...	...	...	×	...	×	...	...	...	...	...	...	...
Natica concinna Dunker.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Neptunea arthritica Val.	×	×	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Neptunea gracilis Costa.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Neptunea islandicus Chem.	...	×	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
?Odostomia planata Gould.	×	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Odostomia subplanata Gould.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oliva (Olivella) consobrina Lischke.	×	...	×	...	...	...	?	...	...	×	...	...	...	...	...	...	...

	1. Tōkyō.	2. Yokohama.	3. Shimōsa.	4. Sagami.	5. Kunō-zan.	6. Kazusa.	7. Tōtōmi.	8. Mino.	9. 'Ashigara T.'	10. Hitachi.	11. Kii.	12. Tosa.	13. Koe-shima.	14. Kanazawa.	15. Sawane.	16. Chichibu.	17. Hokkaidō.
?Patella amussiata Reeve.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Patella Lamanoii Schrenck.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Philine japonica Lischke.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pleurotoma difficilis Smith.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Pleurotoma tigrina Lam.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Purpura lapillus L.	×	×	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Purpura luteostoma Chem.	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Rapana bezoar L.	×	×	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...
Ringicula arctata Gould.	×	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Scalaria alathratula Mont.	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Scalaria cancellata Broc.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sigaretus japonicus Lischke.	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Siphonaria cassidariæformis Reeve.	×	×	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...
Skenea cornuella Adams.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tornatina exilis Dunker.	×	×	...	×	...	...	...	...	...	...	...	×	...	...	...	...	...
Trichotropis coronata Gould. (T. unicarinata).	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
?Tritonium pericochlion Schrenck.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Trochus argyrostoma Gmel.	×	×	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
Trochus shinagawaensis Yoshiwara.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trophon Gunneri Loven.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Trophon granulatus Gmel.	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Turbo granulatus Gmel.	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Turritella communis Risso.	...	...	...	...	...	...	×	×	...	×	...	...	×	...	...	...	...
Turritella erosa Couthony.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Vermetus imbricatus Dunker.	...	×	...	...	...	...	...	×	...	?	...	...	...	...	...	...	...
Voluta megaspira Sow.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
SOLENOCONCHÆ.																	
Dentalium costatum Sow.	...	×	...	×	×	...	×	...	...	...	...	...	...	...	...	...	...
?Dentalium entale L.	×	×	...	...	×	...	×	...	...	...	×	...	...	×	...	×	...
Dentalium hexagonum Lam.	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Dentalium octogonum Lam.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dentalium pseudoentalis L.	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
CONCHIFERA.																	
?Anomia patelliformis L.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Arca granosa L.	...	×	×	...	...	...	×	...	...	...	...	...	...	...	...	×	...
Arca inflata Reeve.	×	×	...	×	...	×	...	×	...	...	...	...	...	...	...	...	...
?Arca subcrenata Lischke.	×	×	...	...	...	...	...	...	...	...	×	...	...	?	...	...	...
Aulus pulchellus Dunker.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...

	1. Tōkyō.	2. Yokohama.	3. Shimōsa.	4. Sagami.	5. Kunō-zan.	6. Kazusa.	7. Tōtōmi.	8. Mino.	9. 'Ashigara T.'	10. Hitachi.	11. Kii.	12. Tosa.	13. Koe-shima.	14. Kanazawa.	15. Sawane.	16. Chichibu.	17. Hokkaidō.
tunda Yoshiwara.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
alaris Sow.	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Braunsii Yoshiwara.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
californiense Desh.	×	×	×	...	...	...	...	×	×	×	...	...	...	...	...	×	...
groelandicum Chem.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
islandicum Falv.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
muticum Reeve.	×	×	×	...	...	...	...	×	...	×	...	...	...	...	...	...	...
le disjuncta Gabb.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	×	×
rythrodon Lam.	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
inensis Gmelin.	×	×	×	...	...	...	...	×	...	...	...	...	...	?	×	×	...
meretrix L.	×	×	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...
a orbella Gould.	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
a trigonula Brown.	×	×	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...
a exoleta L.	×	×	×	...	...	...	×	×	×	×	...	...	?	...	...	?	...
aponica Reeve.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Troschelli Lischke.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
borbicularis Mont.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
um bullatum Adams.	×	×	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...
ra Mont.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
fusa Hanley.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...
amosa Lam.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	×	...
anomala Eich.	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
aurita Broc.	×	...	...	...	...	...	...	...	...	...	...	×	...	?	...	...	...
realis L.	×	×	×	×	...	×	...	×	...	×	×	...	×	...	×	×	...
utilineata Conrad.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Nuttali Conrad.	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
labellata Gould.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
valis Gould.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
chalinensis Schrenck. sulcataria Desh.)	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...
neriformis Desh.	×	×	...	...	...	...	...	×	...	...	...	...	...	×	...	×	...
cavata Hanley.	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
aria L.	...	×	...	...	...	...	...	×	...	...	...	...	...	...	...	×	×
a Grevingk.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
fluctuosa Gould.	×	...	...	...	...	...	...	...	?	...	...	...	...	...	...	...	...
labellata Gould.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...
bboldiæ Sow { N. mirabilis N. insignis.	×	×	...	×	×	...	...	×	...	×	...	×	×	×	...	...	...
ronaica Yokoyama.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×

	1. Tōkyō.	2. Yokohama.	3. Shimōsa.	4. Sagami.	5. Kunō-zan.	6. Kazusa.	7. Tōtōmi.	8. Mino.	9. 'Ashigara T.'	10. Hitachi.	11. Kii.	12. Tosa.	13. Koe-shima.	14. Kanazawa.	15. Sawane.	16. Chichibu.
Ostræa denselamellosa L.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Ostræa gigas Thunberg	×	×	...	...	...	×	×	×	...	×	×	...	...	×	...	×
?Ostræa rivularis Gould	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...
Panopæa generosa Gould	×	×	×	...	...	...	...	...	...	...	...	×	...	...	...	×
?Pecten islandicus Müller.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pecten lætus Gould.	×	×	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Pecten laqueatus Sow.	×	×	×	...	×	...	...	...	...	...	...	...	...	×	...	×
?Pecten plica L. (P. n. sp.)	×	×	...	×	×	...	...	×	...	...	...	...	...	...	...	...
Pecten swifti Bernardi.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	×	...
Pecten yessoënsis Jay.	×	...	...	×	...	×	...	×	...	...	...	...	...	×	×	...
Pectunculus albolineatus L. (P. glycimeris).	×	×	×	×	...	...	...	...	...	×	×	×	×	×	...	...
Saxicava arctica L.	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Saxidomus purpuratus Sow.	×	×	...	...	...	...	...	×	...	×	...	...	...	×	...	...
?Solen grandis Dunker.	×	×	×	...	...	...	...	×	×	?	...	?	...	...	...	...
Soletellina Boeddingshausii Lischke.	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Tapes decussatus L.	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tapes euglyptus Phil.	×	×	...	...	×	...	×	...	...	...	×	...	...	...	...	...
Tapes ezoensis Yokoyama.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tapes rigidus Gould	×	...	...	...	...	...	...	...	...	...	...	...	...	?	...	×
Tapes schnellianus Dunker.	...	...	...	...	...	...	×	...	×	...	...	...	...	...	...	...
Tellina iridella Martens.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Tellina nasuta Conrad.	×	×	×	×	...	...	×	×	?	?	...	...	...	?	...	...
Tellina nitidula Dunker.	×	×	×	...	×	...	×	...	...	...	...	×	...	...	...	...
?Tellina prætexta Martens	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Tellina jeddoensis Lischke.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Venericardia compressa Yok.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Venus Stimpsoni Gould	×	...	...	...	...	...	...	...	×	...	×	...	?	×	...	×
Venus undatella Sow.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Venus jeddoensis Lischke	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Yoldia arctica Brod.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Yoldia autria Brauns	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...
BRACHIOPODA.																
Terebratulina caput-serpentis L.	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	×
Waldheimia Grayi Dav.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Fossil shells with narrow distribution, from the localities not mentioned in the table, are given below:—

Argonauta n. sp.
Columbella compta L.
Cyclichna cylindracea PEN.
Pleurotoma oxytropis SOW.
Potamides fluviatilis P. et H.
Rotella gigantea LES.
Triton sauliæ L.
Turbo mekamiensis NISHIWADA.
Vicarya callosa MARTENS.
Volutharpa Perryi JAY.
Clementia papyracea GRAY.
? *Diplodonta dilatata* WOOD.
? *Diplodonta rotundata* MONT.
? *Lucina crenulata* WOOD.
? *Lutraria elliptica* LAM.
Mercenaria Stimpsoni GOULD.
Mytilus edulis L.
Nucula nucleus L.
Sunetta excavata HANLEY.
Tapes philippinarum AD. et RVE.

The few hitherto recognized extinct molluscan species are as follows:—

Conchocele disjuncta GABB. (Pliocene? of California.)
Vicarya callosa MARTENS (Miocene of Java).
Venericardia compressa YOKOYAMA.
Nucula poronaica YOKOYAMA.
Tapes ezoensis YOKOYAMA (probably Tertiary).
Turbo mekamiensis NISHIWADA.
Plagiostoma sp.
Argonauta n. sp.
Pecten n. sp. (= ? *P. plica*).
Cardium Braunsii YOSHIWARA.

Trochus shinagawaensis Yoshiwara.
Cardita rotunda Yoshiwara.
Diplodonta trigonula Brown} extinct in the Japanese
Lucina borealis L. } seas.

Genera of Mollusca not represented by the species in the table or among those mentioned above are as follows :—

Aclis, *Acmæa*, *Actæon*, *Cerithium*, *Clavatula*, *Conus*, *Cypræa*, *Eulimella*, *Fissurella*, *Hydrobia*, *Lachesis*, *Melania*, *Murex*, *Amestus*, *Paludina*, *Pileopsis* (?), *Planorbis*, *Pyrula*, *Rissoa*, *Stomatica* (?), *Surcula*, *Teredo*, *Turbonilla*, *Volvula*, *Xenophorus*, *Zizyphius*, *Anatina*, *Anodonta* (?), *Astarte*, *Avicula*, *Cæcella*, *Callista* (?), *Capsa* (?), *Capulus*, *Castræa*, *Chama*, *Circe*, *Codokia*, *Cochlodesma*, *Corbicula*, *Crassatella* (?), *Cucullæa*, *Cultellus*, *Cypricardia* (?), *Cyprina*, *Cyrena*, *Glycimeris*, *Gonphina*, *Isocardium*, *Modiola*, *Nærea*, *Paludina*, *Pholas*, *Perna*, *Petricola*, *Pholadomya* (?), *Placuna*, *Psammobia*, *Ræta*, *Selecurtus*, *Spondylus*, *Solenomya*, *Thracia*, *Lingula*, *Terebratula*.

In Tertiary or rather post-Miocene strata teeth and bones of mammals occur in many localities. They are as follows.

Elephas :—Tabata near Tōkyō, Edo-bashi in Tōkyō, Yokosuka in Sagami, Ryūge in Ōmi, Shōzu-shima in Sanuki, Hishiike in Mikawa, Kasumiga-ura in Hitachi, Tomuro-yama in Kaga, Sapporo in Hokkaidō, Kii, Mino, Iyo.

Stegodon :—Shōzu-shima in Sanuki, Hishiike in Mikawa, Ryūge in Ōmi.

Ursus.—Tokiwa in Hitachi,

Cervus :—Sanuki, Shinano.

Bison :—Shōzu-shima.

CHAPTER VII.

CAINOZOIC GROUP.

The two great divisions of the Cainozoic Group are represented in Japan. The Tertiary system yields abundant fossils and the existence of Miocene and Pliocene formations has been recognized by Nathorst, Brauns, and other scholars. But the thorough stratigraphical classification of the Tertiary System is yet to be worked out. The Quaternary System is divided into Diluvium and Alluvium; the former is not characterized by any fossils and its lowest limit toward the Tertiary has been hitherto only vaguely defined.

The beginning of the Cainozoic or the end of the Mesozoic Period was marked by great tectonic movements which shook the foundations of the Japanese Islands. The island-arc of Japan Proper was flexed and broken at its middle and the result was the partition of Northern and Southern Japan, each with a different geological structure. Other minor dislocations caused the division of the land into many 'horsts'; in Southern Japan the mountain-blocks of Kyūshū, Shikoku, Kii Peninsula, and Akaishi remained on the outer side, and the masses of the Tsukushi Mountains, with Chūgoku, Tamba and Hida Plateaus on the inner side. The greater part of Northern Japan was depressed under the sea and a great lateral thrust broke up the linear arrangement of mountain-masses into what we now see.

The chief structure-lines of these tectonic movements run north and south. The direction of the structure-lines is particularly well seen in Northern Japan, namely in the mountain-masses of Kitakami, Abukuma, and Kwantō, and in the course of the Himegawa and along the eastern wall of the Akaishi Mountains on the boundary of Northern and Southern Japan. Southern Japan is also cut by many north-south dislocations which produced a series of triangular peninsulas pointing to the south. Northern Kyūshū has numerous gulfs, filled up by the Tertiary formation, running north and south across the older rocks. These remarkable tectonic lines in the N.—S. direction seem to be ascribable to the posthumous action of the east-west wave of pressure which caused the Ryūkyu Arc and the foundation of the island-chain of Shichitō, rather than to the wave of pressure that diverged from the direction of the Sea of Japan.

The Quaternary Period and the end of the Tertiary Period witnessed the greatest manifestation of volcanic activity. The volcanoes broke forth with great vigour on the weak lines, forming many distinct volcanic chains especially on the inner side of the island-arcs. These chains were noticed in the topographical chapter.

I. TERTIARY SYSTEM.

The Tertiary System constitutes a large and important portion of Japan. The rocks consist of sand, gravel, clays, tuffs, sandstones, shales and conglomerates, with intervening layers of limestone, marl, coal seams, and diatom-earth. Tuffs are very widely prevalent and sandstones and shales assume very frequently a tufaceous character.

The comparative study of the fossil remains which are abundantly found in the Tertiary System, is yet too imperfect to allow the chronological subdivisions to be firmly established. Pliocene and Miocene beds have been recognized, the former chiefly by shell remains and the latter by plants and a few foraminifera. But the localities of the Miocene and Pliocene

Rhinoceros:—Tsukiyoshi in Mino (resembling *R. sivalense*), Hazaki and Togari in Mino.

Delphinus:—Shinano, Hitachi.

A new genus of *Sirenia?*:—Togari in Mino.

Whales:—Mizuho in Kai, Doke in Kazusa, Seki in Kaga, Hitachi, etc.

Sus japonicus, Yoshiwara:—Ryūge, Ugo.

Equus, *Bos*.

Naumann[1] described the fossil elephant-teeth of Japan as belonging to the following species:—

Stegodon Clifti Falconer & Cautley sp.	Pliocene	Siwalik of India.
Stegodon insignis Falc. & Caut. sp.	Pliocene and post-Pliocene	
Elephas namadicus Falc. & Caut.	post-Pliocene of India.	
Elephas primigenius Blum....	post-Pliocene.	

Of many localities that have yielded remains of *Elephas* and *Stegodon* none but Tabata, in the suburbs of Tōkyō, supplies definite information as to the horizon in which they were imbedded.

Shark's teeth are found in several parts of Japan, often accompanied by shells; they include

Carcharodon megalodon Ag. (Miocene of Malayan Archipelago.) Found at Zushi, Uraga, Yokosuka in Sagami, Shimoda in Izu, Mito and Ashiarai in Hitachi, Gejō in Shinano, &c.

Notidanus serratismus Ag. Miyata in Hitachi.

Lima.

Corax.

Oxyrhina.

Sphyrina.

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[1] Ueber japanische Elephanten d. Vorzeit. Palæontographica, N.F., Bd. XXVIII. Heft I, 1881.

Of echinoids, *Scutella* and *Spatangus* are found widely. The following belong to extinct species:—

Astriclipeus integris YOSHIWARA.[1] (Only one fossil genus and species. Found in Taiwan and Honshū.)
Linthia nipponica YOSHIWARA.[1] (In Honshū.)
Schizaster recticanalis YOSHIWARA.[1]
Echinodiscus sp. (Abundant in Taiwan.)

A living species, *Fibularia acuta* YOSHIWARA, is also found as fossil.

Among foraminifera, *Orbitoides* (*Lepidocyclina*) is most characteristic. The *Orbitoides*, often accompanied by *Lithothamnium*, are found in the Tertiary limestones of several places. According to R. Jones, the *Orbitoides* found in the marl of Kamikosaka belong to *O. dispansus* occurring in the Eocene of Europe. But according to the later examination of Verbeek this *Orbitoides* belongs to the group of *Lepidocyclina* which occurs in the Malayan Archipelago in the Neogene Tertiary, probably of the Miocene age. *Orbitoides* (*Lepidocylina*) *Verbeeki* NEWTON and HOLLAND occurs in Taiwan. *Rotalia*, *Globigerina*, *Biloculina*, *Dentalina*, *Crystellaria*, *Nodosaria*, etc. are abundant in younger formations.

Well preserved insects are found in the plant-bed of Shiobara in Shimotsuke.

Crinoids (from Chichibu) and Asteroids (from Hokkaidō and Hitachi) have been found very rarely in the Tertiary strata.

At Mogi in Hizen, Shiobara in Shimotsuke, Yokohama and Ōji in Musashi, etc. fossil plants belonging to the younger group are obtained, in many cases near the horizon of the uppermost shell bed.

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[1] S. Yoshiwara: On some new fossil Echinoids of Japan. Journ. Geol. Soc. Tokyo, 1899, vol. 6, No. 65.

A. G. Nathorst[1] considers Mogi plants as post-Miocene (belonging to the end of the Tertiary or the beginning of the Quaternary), and plants of other localities as a little younger than those of Mogi. The plants include many species yet living in Japan and other countries. According to Nathorst, the floras of Mogi and Yokohama indicate a colder climate than that now prevailing in those regions.

Most of the Mogi flora are very intimately related to the species now living in Japan. *Fagus ferruginea* and *Taxodium distichum*, which are abundantly found as fossils, are extinct in Japan, but live in America. *Rhus Griffithsii*, also not found now in Japan, is known in the Himalayan forest.

De Saporta noticed on the resemblance of the Mogi flora to the mountain flora of the older Pliocene Cinerite of Cantal in France and presumed that the Mogi flora might also belong to the same Pliocene period.

Nathorst recognized the following species from the Mogi plant-bed :—

Taxodium distichum var.
Phyllites bambusoides Nath.
Salix (?) sp.
Betula (?) sp.
Juglans Sieboldiana Max. fossilis Nath.
Juglans Kjellmani Nath.
Carpinus subcordata Nath.
Carpinus stenophylla Nath.
Carpinus sp.
Ostrya virginica Willd. fossilis Nath.
Fagus ferruginea Ait. fossilis Nath.
Quercus Stuxbergii Nath.
Zelkova Keaki Sieb. sp. fossilis Nath.
Ulmus sp.
Aphanante viburnifolia Nath.
Celtis Nordenskiöldi Nath.
Lindera sericea Bl. fossilis Nath.
Lindera (?) sp.
Exocœcaria japonica J. Muell fossilis Nath.
Styrax Obassia S. et Z. fossile Nath.
Styrax japonicum S. et Z. fossile Nath.

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[1] Contributions à la flore fossile du Japon. Kongl. Svenska Vetenskaps-Akademiens Handlingar, Bandet 20, No. 2, 1883.

Zur fossilen Flora Japan's. Palæontologische Abhandlungen, Bd. IV, Heft 3 1888.

Diospyros Nordqvisti Nath.
Diospyros Mogiana Ett.
Clethra Maximoviczi Nath.
Tripetaleja Almquisti Nath.
Vaccinium (?) Saportanum Nath.
Viburnum sp.
Acanthopanax acerifolium Nath.
Liquidambar formosana Hance fossilis Nath.
Deutzia scabra Thunbg. fossilis Nath.
Prunus Buergeriana Miq. fossilis Nath.
Prunus sp.
Sorbus Lesquereuxi Nath.
Cydonia chloranthoides Nath.
Sophora (?) fallax Nath.
Rhus Griffithsii Hook. fil. fossilis Nath.
Rhus Engleri Nath.
Meliosma myriantha S. et Z. fossilis Nath.
Acer Nordenskiöldi Nath.
Acer pictum Thunbg. fossile Nath.
Rhamnus costata Maxim. fossilis Nath.
Vitis labrusca L. fossilis Nath.
Ilex Heeri Nath.
Zanthoxylon ailanthoides S. et Z. fossile Nath.
Dictamnus fraxinella Pers. fossilis Nath.
Elæocarpus photiniæfolia Hook. et Arn. fossilis Nath.
Tilia sp.
Tilia distans Nath.
Stuartia monadelpha S. et Z. fossilis Nath.
Magnolia Dicksoniana Nath.
Magnolia sp.
Clematis Sibiriakoffi Nath.
19 species of Phyllites of imperfect preservation.

Plant fossils belonging to the younger series, not found in the Mogi flora but found in other localities, are as follows :—

Pinus sp.
Cyperus sp.
Bambusa sp.
Cyperites sp.
Acer sp.
Acer arcticum Heer.
Acer Hilgendorfi Nath.
Acer mandshuricum Max. (?)
Acer palmatum Th. (?)
Acer paxi Nath.
Alnus sp.
Araliphyllum Naumanni Nath.
Betula sp.
Betula alba L.
Betula sublenta Nath.
Carpinus sp.
Carpinus subjaponica Nath.
Castanea sp.
Castanea vulgaris Lam fossilis Nath.
Cercidiphyllum sp.
Cercidiphyllum japonicum S. et Z.
Cinnamomum sp.
Clethra barbinervis S. et Z.
Cornus submacrophylla Nath.
Corylus sp.
Fagus intermedia Nath.
Fagus japonica Max. fossilis Nath.
Fagus Sieboldia Endl.
Fagus sylvatica Z.
Hœveniphyllum Thunbergi Nath.

Leguminositis sp.
Myliophyllum sp.
Polygonum cuspidatum S. et Z. fossilis Nath.
Populus sp.
Quercus sp.
Quercus crispula Bl. fossilis Nath.
Quercus dentata Th. (?)
Salix sp.
Stuartia sp.
Silia sp.
Zizyphus sp.

The older or pre-Pliocene flora which were determined by Nathorst include the following species. Both the European and Arctic elements are found in them.

Those indicated with * occur in the Tertiary flora of Europe and those with + are found in the Tertiary flora of the arctic regions.

Abies sp.
Pinus sp.
+Sequoia disticha Hr.
*+ „ Langsdorfii, Brgn.
*+ „ Tournalii Brgn.
*+Taxodium distichum miocenum Hr.
Torreya sp.
+Acer arcticum Hr.
„ Paxi Nath.
Aesculiphyllum majus Nath.
„ minus Nath.
Aesculus sp.
*+Alnus Kefersteinii Gp. var.
„ nostrum Ung.
*+Betula Brongniarti Ett. var.
*+Carpinus grandis Ung.
* Carpiniphyllum pyramidale Gp.
*+Castanea Kubinyi Kov.
*+ „ Ungeri Hr.
* Cinnamomum cfr. polymorphum Hr.
Comptoniphyllum japonicum Nath.
„ Naumanni Nath.
Diospyros brachysepala Al. Br.
+Fagus Antipofi Hr.
Fagophyllum Gottchei Nath.
*+Juglans acuminata A. Braun.
+Juglans nigella Hr.
Lauriphyllum Gaudini Nath.
Liquidambar formosana Hance fossilis Nath.
* Planera Ungeri Ett.
Platanus sp.
Populus sp.
Populus arctica Hr.
Pterocarya cfr. denticulata A. Webr.
+Quercus cfr. grönlandica Hr.
* Querciphyllum cfr. Lonchitis Ung. sp.
*+Salix Lavateri Hr.
Sapindiphyllum dubium Nath.
Trapa borealis Hr., var major Nath.
Ulmus elegantior Nath.
Vitiphyllum Naumanni Nath.
* Zizyphus tiliæfolius Ung. sp.

The chief localities yielding pre-Pliocene plants are Hokkaidō, Ani in Ugo, the coal mines of Iwaki, and Kita-aiki in Shinano. Two kinds of fossil plants, one allied to the pre-Pliocene and the other to the post-Miocene plants are found together near Asano, Shimo-ina-gōri, in the Province of Shinano. The two species of *Taxodium distichum* and *Liquidambar formosana fossilis* are found in the pre-Pliocene flora of Ani and also in the post-Miocene flora of Mogi.

Lithothamnium is found in Tertiary limestone, often accompanied by *Orbitoides*. *Lithothamnium ramosissimum* REUS is found at Sagara in Tōtōmi and other places in Honshū. *L. Rosenbergi* MARTENS, which is found in the Miocene of Java, occurs in Taiwan.

Diatoms are found in Hokkaidō and Kyūshū. Pantocsek,[1] of Hungary, has described many forms of them from the thick deposits of diatom-earth in Hokkaidō. The Japanese fossil diatoms include the following genera:—

> *Amphora*, *Arachnoidiscus*, *Auliscus*, *Aulacoidiscus-Asterolampra*, *Actinoptychus*, *Babliarium*, *Biddulphia*, *Coscinodicus*, *Creswellia*, *Cocconeis Ceratanlus*, *Cam*, *pylodiscus*, *Clavicula*, *Cymbella*. *Dictyocha*, *Diatoma*, *Dicladya*, *Epithemia*, *Eunotia*, *Fragillaria*, *Gephyria*, *Grammatophora*, *Isthmia*, *Melosira*, *Navicula*, *Paralia*, *Rhabdonema*, *Raphoneis*, *Rutilaria*, *Stephanodiscus*, *Salaria*, *Surirella*, *Synedra*, *Triceratium*, *Terpsinoë*, *Stylobiblium*.

From the standpoint of lithological character and geologica structure the Tertiary formation of Japan is divisible into two. In the younger of the two divisions, the strata, consisting of loose, soft rocks such as sand, gravel, clay, soft sandstone, shale, and tuff, show no remarkable folding, and lie in

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Beiträge zur Kenntniss der fossilen Bacillarien Ungarns, 1892.

most cases nearly horizontally. They are directly covered by Diluvium and there is no manifest unconformability between them and the latter. They are seen widely developed in the neighbourhood of Tōkyō and Yokohama, the Provinces of Owari and Omi, and portions of Kinai and Chūgoku. The strata belonging to the other category consist of rather harder and more compact rocks and are tilted and folded, showing considerable contortions in not a few cases. They have a wider distribution than those previously mentioned, and constitute high hilly regions. Unconformability between the two has been observed near Shiobara in Shimotsuke and in Kazusa, etc.

We take up the description of the Tertiary System in the whole empire in the following order:—

1. Northern Honshū.
2. Southern Honshū and Shikoku.
3. Kyūshū.
4. Hokkaidō.
5. Taiwan, Ryūkyū, and Ōshima Islands.

1. **Northern Honshū.**—A great portion of the Kwantō Plain consists of low, flat hills, or rather elevated plains commonly 20–40 meters higher than the alluvial plains. The bluffs at the ends of the elevated plains expose a series of nearly horizontal strata of which the lower beds below the uppermost fossil layer inclusive are commonly considered as the Tertiary and the upper portion as the Diluvial System.

The Tertiary of the neighbourhood of Tōkyō and Yokohama has been best studied, and the fossils contained in it form the basis of comparison of Tertiary fauna. Throughout these regions stratigraphical successions are nearly the same, only with a few minor differences. A section is given in Fig. 2 of the various beds exposed at Ōji in the suburbs of Tōkyō. There and at Tabata clay containing the impressions of leaves is separated from the uppermost loam by clay and gravel without any unconformability between; a little lower lies a sandy layer with abundant shells. At Tabata teeth of *Elephas* and bones of mammals have been found in the sandy layer between the plant bed and the shell bed.

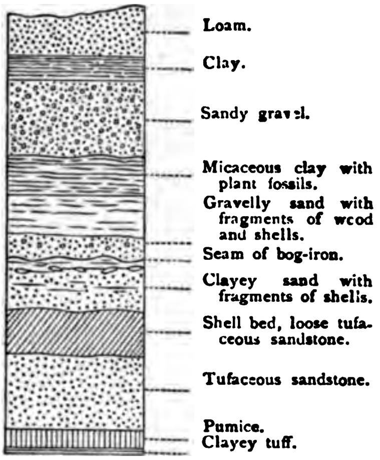
Loam.
Clay.
Sandy gravel.
Micaceous clay with plant fossils.
Gravelly sand with fragments of wood and shells.
Seam of bog-iron.
Clayey sand with fragments of shells.
Shell bed, loose tufaceous sandstone.
Tufaceous sandstone.
Pumice.
Clayey tuff.

Fig. 2.—Section at Ōji mill, 1/500.
(After Suzuki.)

D. Brauns[1] enumerated 87 species of shells from the neighbourhood of Tōkyō and Yokohama. According to him, 69 of that number belong to the species now living in the Japanese and Chinese seas, and the remaining 18 to species now extinct in the neighboring seas, and he concluded that the shell bed is Pliocene and has a close faunal resemblance to the English Crag. This conclusion has been adhered to by later investigators and all the younger shell beds are included in the Tertiary.

In view of the latest researches of S. Yoshiwara the allegation of resemblance of Ōji fauna to the Crag fauna seems groundless as all the species certainly common to both are cosmopolitan. Yoshiwara mentions 74 Lamellibranchs, 3 Scaphopods, 3 Brachiopods, and 70 Gasteropods from Ōji and Shinagawa. According to him the fossil fauna of the environs of Tōkyō indicates a colder climate than that now prevailing in the region, and of the numerous shells those that may be regarded as extinct species with greatest probability number only 6. They are as follows:—

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[1] Geology of the Environs of Tokyo, 1881.

Cardium Braunsii YOSHIWARA,
Trochus shinagawaensis YOSHIWARA.
Cardita rotunda YOSHIWARA.
Diplodonta trigonula BROWN (extinct in the Japanese seas).
Lucina borealis L. (extinct in the Japanese seas).
Pecten n. sp. (= ? *P. plica.*)

The Tertiary in the peninsulas of Awa-Kazusa and of Miura consists of folded strata of tuffs, sandstone, shale, and conglomerate of harder character than the rocks just mentioned, which yield shells and shark's teeth.

In Shimōsa and Kazusa the younger series of the vicinity of Tōkyō extend eastward and they are bounded unconformably by the older Tertiary of the south.

The Tertiary in the small basin of Itsukaichi west of Tōkyō contains lithographic marl and yields Miocene plants and crabs; its strike is N. — S. The Miocene plants are *Castanea Kubinyi*, *Juglans acuminata*, *Planera Ungeri ?*, *Comptonia acutiloba*, *Castanea Ungeri*, *Aesculus*, *Fagus*.

The Tertiary exposed in the north and west of Ōyama in Sagami, as a belt surrounding the Misaka Series of Doshi, consists mainly of hard green tuff with andesite sheets. North of Fuji near Yoshida, bones and teeth of *Physterinæ*, teeth of *Myliobites cornuata* GTHR, *Astriclipeus integris* and shark's teeth, together with shells, are found in green tuff, and the limestone on the shore of Lake Kawaguchi yields *Orbitoides* and *Lithothamnium*.

From the north of Hakone to the peninsula of Izu, white and green tuffs peep at intervals from beneath the cover of volcanics; they yield shark's teeth, and the limestone layer of Nashimoto in Izu contains foraminifera and *Lithothamnium*.

The Tertiary on the Fuji-kawa may be divided into two;

the upper constituting the low-land on the banks is tufaceous while the lower Tertiary in the higher hills is not tufaceous and contains abundant foraminifera. The strata run N.—S. with westward dip in the north; they are disturbed and folded in the south.

In the basin of Chichibu in Musashi the order of superposition is the undermost conglomerate, sandstone, sandstone and shale, and the uppermost shale; there occur abundant shells having much in common with those in the environs of Tōkyō, except *Conchocele disjuncta*, *Plagiostoma* and a few other shells not found in the latter. The main axis of folding is N. E.—S. W.

Of the Tertiary on the north-eastern fringe of the Kwantō Mountains, the northern is younger and tufaceous; it contains *Conchocele* and lignite beds which yield plant leaves. The strata dip gently northward. In the south the vicinity of Shimonita in Kōzuke consists of shale with Pliocene shells. *Orbitoides* (*Lepidocyclina*) is found in marl in Kami-kosaka near Shimonita. The general strike is parallel to the Kwantō Mountains.

In the valley of Kita-aiki in the western Kwantō Mountains occur plant-beds with the Miocene forms, such as *Sequoia Tournalii ?*, *Betula Brongniarti*, *Fagus Antipofi*, *Castanea Ungeri*, *Planera Ungeri*, *Juglans nigella*, *Vitiphyllum Naumanni*, *Torreya*, *Phyllites*.

On the eastern side of the Abukuma Mountains, in Iwaki and Hitachi, the Tertiary strikes N.—S., dipping mainly to the east. The lower portion consists of tufaceous sandstone containing coal-seams which are extensively worked. The upper portion consisting of conglomerate, sandstone, and tufaceous shale, with numerous Pliocene shells, dips very gently eastward. Liparitic sandstone belonging to the uppermost zone outcrops on the coast of Hitachi. It yields abundant fossils at Isowara, Ōse, Sukegawa, etc.

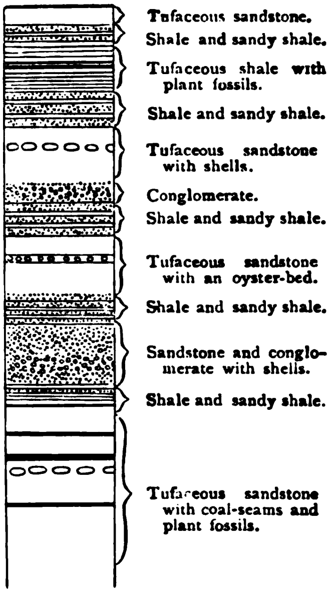
Tufaceous sandstone.
Shale and sandy shale.
Tufaceous shale with plant fossils.
Shale and sandy shale.
Tufaceous sandstone with shells.
Conglomerate.
Shale and sandy shale.
Tufaceous sandstone with an oyster-bed.
Shale and sandy shale.
Sandstone and conglomerate with shells.
Shale and sandy shale.
Tufaceous sandstone with coal-seams and plant fossils.

Fig. 3.—Columnar section of the Tertiary strata on the eastern side of the Abukuma Mountains, in Iwaki and Hitachi. (After Ōtsuka.)

On the south-west of the Abukuma Plateau, the Tertiary strata deposited in the valleys of the Yamizo Range are of conglomerate, sandstone, and shale, with tuff in the west; they contain thin coal-seams and plant remains.

In the small Tertiary area in the vicinity of Shiobara Hot Springs in Shimotsuke, the upper portion consists of tufaceous shale yielding excellent specimens of the post-Miocene plants. The unconformably underlying strata are mainly beds of thick liparitic tuff with fossil shells, many of which differ decidedly from those of the environs of Tōkyō. N. Kanehara distinguishes the following fossil beds:—

1. (The uppermost.) Gray tuff with *Ostrea*, *Pecten*, *Arca*, *Lucina* cfr. *acutilineata*, *Cardium*, *Venus*, *Tellina*, *Solen*, *Natica*.
2. Sandstone with *Pecten*, *Mytilus*, *Modiola*, *Arca* *Venus*, *Cytherea*, *Dosinia*, *Tellina*, *Panopæa*, *Natica*, *Sigaretus*.
3. Tuff, often conglomeratic, with *Pecten* and *Ostrea*.
4. Bed with *Pectunculus* and *Arca*.

Further northward, the Tertiary covering the greater portion of the so-called North-eastern Region in Northern Japan may be divided geographically into two portions by a N.—S. line through the plains of Wakamatsu, Yonezawa, Yamagata and Ōmagari.

The eastern portion consists chiefly of tuffs, closely related with the volcanic eruptives which are so well developed in the neighbourhood. The lower part consists of a thick imperfectly stratified mass of white liparitic tuff, while the upper, forming the prairie-like flat hills, is mainly of green and gray andesitic tuffs with many interstratified sheets of andesites and lignite beds. The fossil content and the topographical features of the latter resemble those of the environs of Tōkyō.

Near Sendai have been found *Saxicava arctica, Panopæa generosa, Pecten plica, Dosinia exoleta,* etc., and at Usu in Iwashiro, *Tellina nasuta, Pecten laqueatus, Lucina borealis, Mactra veneriformis, Cardium muticum,* etc.

The Tertiary in the western part of Northern Japan stretches from Echigo and Shinano on the south-west to the northern end of the main island, and the same formation appears in Sado Island. It contains petroleum and metalliferous veins and is one of the most important repositories of useful minerals in Japan. It may be divided into two parts. The younger, which has received the name of Sawane Tertiary in Sado, consists of rather loose and soft rocks which contain fossil shells. The older, called Aikawa Tertiary in Sado, is of rather harder rocks, which contain coal-seams and pre-Pliocene plant-beds, and are cut by many important metalliferous veins. These two divisions, correspônding to the Pliocene and Miocene, are not always very clearly defined from each other and they have been separately mapped out only on the Island of Sado. Near the Ani Mine, beds of Pliocene shells and Miocene plants are said to occur near to each other, yet we have no information as to the relations of the two different formations.

The uppermost member of the younger series closely resembles the Tertiary of the environs of Tōkyō; it consists of sand and friable argillaceous sandstone containing shells and plant remains, and shows only a small degree of orogenic disturbance. It is exposed along the coast of Echigo, on the eastern margin of the Shōnai plain in Uzen, in the peninsula of Ogashima, and in a few other places.

With the exception of the above-mentioned youngest member, the Tertiary of both series is greatly folded and disturbed. It contains marl, phospatic nodules (in the vicinity of Shinjō in Uzen), radiolarian chert, and interstratified sheets of andesites, basalts, and liparites. In the Kuma-gawa region near Nagano in Shinano, we find a vast development of liparitic and perlitic tuff-breccia. The wide Tertiary region on the borders of Echigo and Iwashiro consists of extensive tuffs derived from andesites, dacites and liparites. The Aikawa Tertiary contains thick masses of dolomite.

In north-western Ugo (Niageba and Hanawa) have been found *Turritella communis*, *Conchocele disjuncta*, *Thracia*, *Terebratula*, *Terebratulina*, *Rynchonella*, *Capulus*, *Natica*, etc.

Pre-Pliocene plants occur in the Ani Mine, Shimo-hinokinai, and Maeda in Ugo, Aburato coal-mine in Uzen, and Nakaji, Minamiba, etc. in the province of Echigo; the following plants have been found.

At Kayakusa and Ōsawagawa in Ani:—*Pinus*, *Taxodium distichum miocenum*, *Sequoia Langsdorfii*, *Castanea Ungeri*, *Castanea Kubinyi*, *Juglans acuminata*, *Juglans nigella*, *Planera Ungeri*, *Cinnamomum* cfr. *polymorphum*, *Trapa borealis*, *Liquidambar formosana*, *Carpinus*.

At Shimo-hinokinai:—*Sequoia Tournalii*, *Pinus*, *Juglans acuminata*, *Comptoniphyllum Naumanni*, *Planera Ungeri*, *Cinnamophyllum*, *Lauriphyllum Gaudini*, *Phyllites*.

At Aburato:—*Fagus Antipofi*, *Alnus Kefersteini*, *Aesculiphyllum minus*, *Abies*, *Sequoia*, *Tilia*.

2. **Southern Honshū and Shikoku.**—In Southern Japan the Tertiary is mostly developed in the inner side, and only insignificantly in Kii Peninsula and Shikoku.

The Tertiary in the Kaga-Etchū region on the Sea of Japan consists chiefly of volcanic clastics containing marls and lava sheets. The general strike is N. E.—S. W. Loose sandy layers occur in the central part of Noto.

In the Tertiary of Kaga, east of the Tetori-gawa, tuff-sandstone at Nishi-ichise have yielded *Operculina*, *Ringicula arctata*, *Odostomia planata*, *Globulus superbus*, *Dentalium entale*, *Cytherea meretrix*, *Cardium muticum*, *Fusus*, *Nassa*, *Yoldia*, *Solen*, *Tellina*, *Tapes*, *Venus*.

In Echizen, plant fossils among which are *Fagus japonica fossilis*, *Polygonum cuspidentum fossilis*, and *Phyllites*, are found in the small outcrop of Ushigatani near Katsuyama in Ono-gōri; and unimportant coal seams are found in a few localities in the western portion of Echizen.

The Tertiary in Tōtōmi and Suruga, west of Shizuoka, is known as the Ōigawa Tertiary. It is divisible into two. The lower on the north, composed of folded shale and sandstone with subordinate tuff and limestone, is exposed along the Mikura Series, into which it seems gradually to merge. The upper, on the south, is tufaceous and forms a wide plateau, covered with thick gravel toward the south. In the southern portion lie the petroleum localities of Haibara-gōri; there the strata are much folded. In the region of the younger Tertiary near Sagara in Haibara-gōri, stand the two isolated limestone cones of Okami and Mekami; they yield *Lithothamium ramosissimum*, *Turbo mekamiensis*, *Stylophora*, *Millipora*, *Pecten*, etc.[1] The axis of folding of the Ōigawa Tertiary runs N. E.—S. W.

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[1] K. Nishiwada: On some organic remains from the Tertiary limestone near Sagara, Tōtōmi. Journ. Col. Sc. Imp. Univ., 1895. vol. VII. pt. 3.

In the Shidara basin in Mikawa Province, the rocks consist of liparitic tuff and sandstone and run N. W.—S. E. In the north-western portion of the basin scanty remains of plants (Miocene?) have been found. The small Tertiary area in the vicinity of Tomikusa, Shimo-ina-gōri, Shinano Province, along the west side of the Tenryū-gawa, yields plant and shell fossils at Asano. Four fossiliferous beds can be distinguished there; the upper-most contains the following shells :—

Pecten pusio, Nucula Cobboldiæ, Cardita scalaris?, Dentalium entale, Mytilus, Modiola, Placuna, Tapes, Arca, Panopæa?, Patella, Turitella.

The second is a tufaceous plant-bed which contains :—

Carpiniphyllum pyramidale japonicum, Castanea cfr. *Kubinyi, Juglans nigella, Liquidambar formosana fossilis?, Vitiphyllum labrusca fossilis?.*

The first three belong to the pre-Pliocene species, but the rest resemble species from the post-Miocene flora of Mogi. The third bed, which is green tufaceous sandstone, contains the following shells :—

Columbella compta, Natica Lamarckiana, Nassa japonica, Dentalum entale, Tellina iridella, Lucina borealis, Ostrea gigas, Cerithium, Tornatina, Dosinia, Solen, Anomia, Nucula, Cullelus, Leda, etc.

The fourth bed consists of tufaceous sandstone with abundant *Ostrea gigas.*

A little northward, the petty Tertiary exposure of Yonegawa on the east of the Tenryū-gawa yields pre-Pliocene plants, such as *Sequoia Langsdorfii, Carpinus grandis, Castanea Kubinyi, Planera Ungeri.*

The neighbourhood of the town of Takayama, Ena-gōri, Mino Province, consists of tufaceous rocks which contain abundant shells at Tsukiyoshi and Togari. Among these is found *Vicarya callosa* MARTENS, which occurs in the Miocene of India and Java. Tsukiyoshi yields a few plant fossils which Nathorst presumes to be younger than the Mogi flora. In the shell bed of Tsukiyoshi a tooth of a rhinoceras resembling *R. sivalense* has been found; teeth of rhinoceras have been found also at Togari and at Hazaki near Togari.

The widely extended Tertiary strata east of the plain of Mino and Owari consist of sand, gravel, pumice and clay in the upper part, and of sandstone and shale in the lower part. The pumice and porcelain-clay in the upper, and lignite of inferior quality, locally called 'Iwaki', in the lower series, are characteristic economic products of this formation. The strata are nearly horizontal or very gently undulated. The same young formation occurs in a portion of the region known as Kinai, i.e., Ōmi, Ise, Iga, Settsu, and Izumi. Shells found in the formation are:—

> *Natica Lamarckiana*, *Lutraria Nuttali*, *Cyclina sinensis*, *Dosinia exoleta*, *Mactra veneriformis*, *Pectunculus glycimeris*, *Tapes decussatus*, *Tellina*, *Solen*, *Venus*, *Lucina*, *Ostrea*, *Turritella*.

The Tertiary rocks of Awaji are conglomerate, arkose sandstone, and shale with lignite. Fossil shells are found in Koe-shima in the northern extremity of the island. On the coast of Sanuki, tuff and agglomerate outcrop from under a thick, flat lava-bed.

The Tertiary scattered in the provinces of Tango, Tajima, Harima, Inaba and Mimasaka may be divided into younger and older. The older formation, covering narrow areas, consists of hard shale with thin limestone and yields a few Miocene plants,—*Ficus* cfr. *tiliæfolia*, *Pterocarpa* cfr. *denticulata*, *Taxodium distichum*, *Salix*, *Acer*, etc., at Kashiwaishi in Inaba. The newer formation, which has a far wider distribution than the older, consists mainly of loose tuff; its topography is generally flat, and it resembles the younger Tertiary of Kinai.

On the coast of Izumo and Iwaki, the upper tufaceous rocks with lignite and pumice, overlying the older sandstone and shale series, contain *Charcarodon*, *Nucula Cobboldiæ*, *Dentalium entale*, *Venus*, *Tellina*, *Nucula*, etc. A new species of *Argonauta*[1] was first found in tuff near Matsue in Izumo. The strike is nearly E.—W. in the lake region, and N. 60° E., with a gentle dip to the north, in the west.

On the Islands of Oki, the Tertiary strata, consisting of sandstone, shale, tuff, and breccia, are found under a cover of volcanics, and contain imperfect plant remains; the strike is N. 20° E., with a gentle dip.

The Tertiary formation near Shōbara, Bingo, consists of sandstone underlaid by shale containing very thin coal layers; it dips gently westward.

In southern Nagato, the series of sandstone and underlying shale contains coal and constitutes the Tertiary coal-field of Nagato; the strata are gently undulated.

The Tertiary near Tanabe in Kii Peninsula, consisting of sandstone and sandy clay with fossils, seems to belong to the younger formation.

In Shikoku the Tertiary has but limited development. The loose sandstone and tuff forming the elevated platform on the coast of Aki-gōri in Tosa, are but little tilted, and contain shells and foraminifera at many places. Besides those mentioned in the table of Tertiary fossils, the following are found: *Operculina complanata*, *Dentalina communis*, *Glaudulina lævigata*, *Pullenia Bulloides*, *Sphæroidina Austuacea*, *Textularia sagittala*.

In the neighbourhood of Ishizuchi-yama, one of the highest regions in Shikoku, a few plant remains are found in tuff, among which are *Textoria* (*T.* cfr. *japonica* Miq.) and *Ficus* leaves.

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[1] S. Yoshiwara, on a new species of Argonauta from the Tertiary of Izumo. Journ. Geol. Soc. Tokyo, 1900. Vol. VII. No. 80.

3. **Kyūshū.**—In the large island of Kyūshū, the Tertiary formation includes many important coal-fields in the northern portion; and it extends widely through the volcanic regions, where it is covered by overlying ash and lava.

The Tertiary deposits of the important coal-fields of Chikuzen aud Buzen, mainly in the basin of the Onga-gawa, lie in narrow depressions running N. W.—S. E., across the older formations and eruptives, nearly at right angles to the strike of the older rocks. The post-Tertiary orogenic force, which acted nearly in the direction of the strike of the older mountains, caused the Tertiary beds to fold into synclines with their axes generally near the eastern margin of the narrow troughs. Coal-seams outcrop in most cases only in the more gently-sloping western wings of the synclines. The rocks are sandstone, shale, and conglomerate. *Conchocele* has been found in a coal pit in Munekata-gōri.

The Tertiary of Hizen Province may be divided into younger and older. The younger formation consists mainly of white and gray tuffs and shale which sometimes cover andesite lavas; the prevalent strike is E.—W., and dips are very gentle. Mogi, near Nagasaki, is famous for its plant fossils, which were first noticed by Nordenskiöld and studied by Nathorst.[1] Most of about 50 certainly determined species of fossil plants found there belong to those now living in Japan. The sediments of volcanic nature exposed in the Tokitsu and Shimabara regions, may belong to the younger formation. The shale and sandstone on the Island of Iki are probably of the same age as the Mogi bed; at Yawata-ura, in this island, occur *Populus*, *Acer*, *Salix*, *Stuartia*,

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[1] Contributions à la flore fossile du Japon, 1883.

Juglans, *Leuciscus*. The older formation has a wide distribution, and includes the Takashima, Karatsu, and many other coal-fields. It appears over the greater part of Hizen and on the numerous adjacent islands. It consists of sandstone and shale; the general strike is N. E.—S. W.

The Tertiary in the Miike region, with the famous coal-mine of Miike in its northern end, consists of sandstone and overlying shale; the eight-foot coal-seam of Miike is contained in the thick sandstone. The strike is N. W.—S. E. in the north and turns to nearly N.—S. in the south.

The Tertiary on the south of the plain of Kumamoto closely resembles the younger formation developed in the Owari and Kinai regions, and consists of loose rocks, such as pumice, sand, clay, gravel, and tufaceous shale.

The loose Tertiary rocks also peep out amid volcanic rocks in Satsuma; they yield *Tellina nasuta*, *Mactra veneriformis*, *Ostrea denselamellosa*, *Ostrea gigas*, *Arca inflata*, *Arca subcrenata*, *Nassa livescens*, *Natica pyriformis*, *Lampania zonalis*.

Near Mori, Kusu-gōri, Bungo, nodules containing diatoms, accompanied by a plant bed with *Myriophyllum*, *Zelkova*, *Fagus*, etc., exist in the small Tertiary area amid volcanics. Among the diatoms from Bungo, A. M. Edwards distinguished *Stephanodicus beroliensis* C.G.E., *Epithemia jurgensu* C.A.A., *Epithemia gibba* C. G. E., *Fragilaria pectinale* O. F. M.; of these the first species is most common, and in view of this fact he regards the probable age of the diatom-bed as later than the Tertiary.

In Hyūga, in south-eastern Kyūshū, the Tertiary deposits form, on the north of the Kaeda-gawa, a broad elevated platform, covered by thick gravel and consist mainly of loose and soft rocks. On the south of the same river, they form a high mountain region gently sloping to the eastern coast, and consisting of a series of sandstone and shale of an enormous thickness, regularly dipping eastward. A thick shell bed, which marks the lower horizon of the series and is sometimes accompanied by calcareous layers containing *Operculina*, can be traced northward from Aburatsu harbour to a point beyond Takaoka, a distance of about 50 kilometers. At Tano, Miyazaki-gōri, have been found, together with abundant remains of crabs,

> *Nucula nucleus*, *Nucula cobboldiæ*, *Tapes* (cfr. *Schnellianus*) *sp.*, *Lucina crenulata ?*, *Diplodonta rotundata ?*, *Diplodonta* (cfr. *dilatata*) *sp.*, *Myodora flexuosa ?-* *Pecten yessoensis ?*, *? Ficus reticulata*, *Dentalium entale ?*, *? Venus sp.*, *Leda sp.*, *Mytilus sp.*, *Dosinia sp.*, *Solen sp.*

To the west of the above mentioned formation and to the south of Aburatsu extends a series of older strata, highly folded and disturbed, which is of doubtful age and might belong to the Mesozoic. Phospatic nodules and layers are found in the strata exposed on the eastern coast south of the mouth of the Kaeda-gawa.

In Tanega-shima we find the continuation of the rocks of Hyūga. The older formation of doubtful age constitutes the foundation and along the coast a few patches of loose Tertiary rocks make their appearance.

4. **Hokkaidō.**—The Tertiary, which attains an enormous development in Hokkaidō, is sometimes petrographically difficult to distinguish from the Cretaceous of the same island. Shale and sandstone constitute the rocks of the coal-fields, east of the Ishikari Plain, extending over the basins of the Yubari, Ikushumbetsu, and Sorachi. In other regions, tuff, sandstone, and tufaceous shale are best developed. Coal-seams are mostly accompanied by pre-Pliocene plants and are considered as Tertiary. But at Yūbari and other coal mines the distinction between the Tertiary and Cretaceous formations seems not very clear, coal-seams being also found

associated with *Ammonites* beds. The thickness of the beds containing coal reaches 4,000 ft. in Sorachi and 3500 ft. in the Yūbari coal-field, and they are underlaid by a thick conglomerate.

The coal beds, where dips are steeper, have generally a N.—S. strike. In Ikushumbets and at the Poronai Mines, the coal beds on the eastern wings of the anticlines dip at pretty high angles. In other districts, generally speaking, dips are very gentle and in many cases beds are practically horizontal. E.—W. strike predominates in the peninsula of Nemuro. The following three divisions of the Tertiary strata have been recognized in Hokkaidō by their fossil contents, although no remarkable difference of lithological characters is observable among them.[1]

1. Miocene plant-bed.
2. Miocene fresh-water bed.
3. Pliocene bed.

Miocene plant fossils are found in the coal-fields of Ishikari and Kushiro; they are

> *Sequoia Langsdorfii*, *Sequoia* cf. *disticha*, *Taxodium distichum miocenum*, *Juglans acuminata*, *Carpinus grandis*, *Populus arctica*, *Alnus nostratum*, *Alnus* aff. *incana*, *Alnus* aff. *maritima*, *Quercus platania*, *Platanus Guillelmœ* (?), *Cephalotaxus*, *Cericidiphyllum*, *Vitis*, *Fagus*, *Acer*, *Equisetum*, etc.

The fresh-water shells in the Miocene are *Cyrena*, *Paludina*, *Anodonta*, etc.

The Pliocene contains plant remains, allied to those found in Saghalien, and abundant fossil shells. The following three shell-beds are distinguished:—

1. *Conchocele* bed, with *Conchocele disjuncta*, *Lucina*, *Solemya*.

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[1] K. Jimbō; General Geological Sketch of Hokkaido, 1892.

2. *Nucula* bed, with *Nucula poronaica*, *Venericardia compressa*, *Hemicidaris*.
3. *Scutella* bed, with *Nucula poronaica*, *Venericardia compressa*, *Ostrea*, *Pecten*, *Scutella*, *Nucula*, etc.

In the Chishima Islands, the islands of Shikotan and Shibots consist of tuff, sandstone, shale and the lowest Tertiary conglomerate, which have an E.—W. strike. The islands of Kunashiri, Etorofu, and Urup consist of tuff which has a close relation with the neighbouring volcanics.

5. **Taiwan, Ryūkyū, and Ōshima Islands.**—The Tertiary rocks on the Islands of Ōshima in the south of Kyūshū are nothing but raised coral reef. In the Ryūkyū Islands we see a greater development of coral limestone which reaches 300 ft. above the sea and forms elevated platforms. The formation of the coral reefs, which contain large *Operculina* and *Lithothamnium nahaense* HEYDRICH,[1] may have begun in Tertiary times and is still proceeding. Small outcrops of sandstone and shale, of loose and young appearance, are seen on the islands of Okinawa and Kume. Iriomote-jima in the Yaeyama group consists chiefly of older Tertiary sandstone and shale, which contain a workable seam of coal.

The Tertiary on the Island of Taiwan occurs in three areas; 1. the Tertiary on the west of the back-bone range, extending through almost the whole length of the island from Cape Sanshō to the basin of the Katansui-kei; 2. the Tertiary on the peninsula of Kōshun; 3. the Tertiary forming the Taitō Coast Range.

The western Tertiary consists of sandstone and shale, the former best developed in the north, and the latter in the south. In the north, many coal-seams are found and also layers of arenaceous limestone in the upper horizons. The lowest shale seems to pass gradually into the older clayslate formation on the west; the transition is observed at Giranchō, Tōi, south of Horisha, and near Suirikō. The fossils found are some plant remains from coal-mines, *Astriclipeus*, *Scutella*, *Echinodiscus*, *Pecten*, *Ostrea*, *Dentalina*, *Orbitoides*, corals, *Lithothamnium*, etc. The strike of the Tertiary is in conformity with that of the clay-slate formation on the west, namely, N. E.—S. W. in the north, turning to N.—S. in the south. Dip, though variable, is commonly gentler in the western side and steeper near the eastern boundary.

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[1] F. Heydrich: Eine neue fossile Alge aus Riukiu. Journ. Geol. Soc. Tokyo, Vol. VII, No. 80, 1900.

The rocks in the peninsula of Kōshun are conglomerate on the upper, and sandstone and shale on the lower horizons. The strike is N.—S. or N. N. E.—S. S. W. and the dip 20°—40° W. or W. N. W. Hot springs gush out from the Tertiary, the most conspicuous being those of Shichō-kei.

The Tertiary forming the Taitō Coast Range consists of shale, sandstone, conglomerate, and tuff. Conglomerate occurs only in the middle portion. Tuff occupies the upper horizons in the northern part, and it is covered in many places by volcanic agglomerate. Layers of metamorphosed coral limestone are sometimes found intercalated in the Tertiary. Hot springs are also found in this region.

II. QUATERNARY SYSTEM.

1. *Diluvium.*

Diluvium consists of alternations of sand, gravel, clay, and pumice, often covered by a fine deposit of volcanic nature. This volcanic deposit is commonly known simply as loam. No fossils from Diluvial strata are known.

According to T. Suzuki, the bluffs in the environs of Tōkyō show the series of Diluvial beds represented in the accompanying diagram.

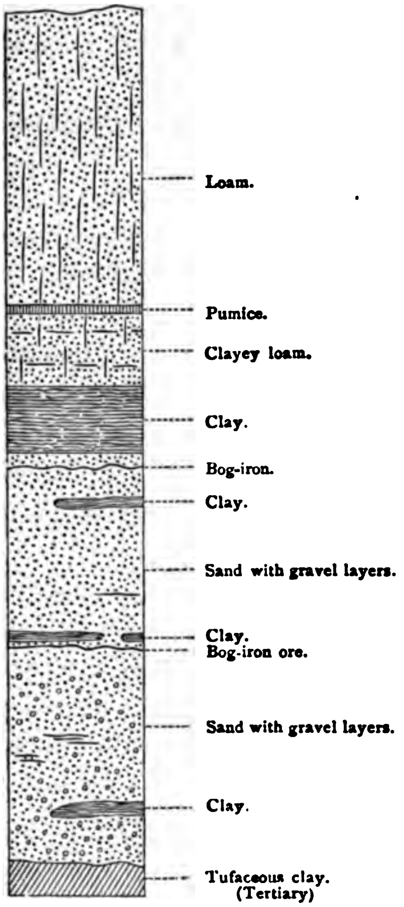

Fig. 4.—A typical section of the Diluvium in the environs of Tōkyō, 1/5000. (Suzuki.)

Loam, the uppermost stratum, is a loose, reddish brown mixture of clayey and sandy materials, commonly called 'red soil.' It forms a homogeneous, non-stratified mass, several metres thick, and has a tendency to split by perpendicular fissures on the faces of bluffs.

Pumice, occurring commonly next to loam, is a loose aggregate of small fragments of yellow decomposed pumice. It attains a thickness of less than 1/2 metre near Tōkyō, but more than 1 meter in the western part of the Kwantō plain.

The clayey loam is dark brownish, and shows some stratification. Often it passes gradually into clay of the next layer.

The clay of the uppermost horizon reaches a thickness of more than 1 metre. The lower clay forms layers of irregular thickness in gravelly sand. This clay is sometimes utilitized in the making of earthen-ware of inferior quality.

The sand is mostly of tufaceous origin. The gravel consists of pebbles of greywacke sandstone, quartzite, clay-slate, diorite, andesite, etc. The layers of sand and gravel attain a thickness of 10 metres. The gravel is dug in Koishikawa, Takata, etc., to be used in making roads in Tōkyō. It contains drift wood and clay-ironstone pseudomorphs after wood.

Thin layers of bog-iron ore are always found just beneath the clay and clayey loam.

Diluvium constitutes the greater portion of the Kwantō plain and it is invariably separated from Alluvium by bluffs 20–40 metres high.

The flats in eastern Hokkaidō are covered with vast pumiceous deposits and gravel layers; the plain of Tokachi is the widest of them. The covering of gravel is seen on the banks of the large rivers of Northern Japan, such as the Kitakami, Abukuma, Naka, etc.

The terraces on the upper courses of the Shinano-gawa and the Tenryū-gawa are covered with thick gravel. The gorges of Ōtagiri and Kotagiri on the Tenryū expose cliffs of gravel nearly 100 metres high.

The wide, elevated, sterile 'haras' of Nunobiki, Iwata, Mikata, Takashi, Toyokawa, etc., extending through the provinces of Tōtōmi and Mikawa, are all covered with gravel which reaches a thickness of 20 metres.

The elevated platform covered with gravel is also found west of Miyazaki in Hyūga.

Diluvial deposits of volcanic ejectamenta partly aqueous and partly subærial, commonly with interstratified sheets of andesite, form wide plains in Kyūshū, namely, those in the vicinities of Kurume, Kumamoto, and Ōita, and the wide undulating tract extending over Satsuma, Ōsumi, and Hyūga.

In the island of Taiwan, the elevated Diluvial platform is found as a long intervening belt between the Alluvial plain on the western coast and the Tertiary hills. The uppermost layer is laterite, reaching a thickness of 10 m.; the next is gravel and sand which is underlaid by clay. Diluvial terraces covered with gravels that are often auriferous, are found in the upper courses of the rivers in the north.

2. *Alluvium.*

The lithological character of Alluvium requires little notice. It consists of fluviatile deposits of sand, gravel, and clay, and sands of beaches and dunes. No general order of succession of strata can be established.

The sea-ward shifting of beach-lines by the increase of Alluvium within historical times is fully attested by the plains at the mouths of many rivers. We give below a few examples of such changes, as shown by some writers by comparison of old and new maps.[1]

Fig. 5 shows the present site of Tōkyō in the Chōgen Epoch (1028—1036 A.D.) and at the present time. From it we see that about 900 years ago, nearly all the lower portion, the so-called 'Shita-machi' of the present Tōkyō, was marsh or shallow sea. Fig. 6 shows again the same relation with respect to Tōkyō between the Chōroku Epoch (1457—1459) and the present time. The extension of the land prior to 1590 was almost solely effected by natural agencies, that is the transportation of soil by the rivers Sumida and Edo and probably also by the upheaval of the land. After that date, natural agencies were assisted by the human in the reclamation of the land. Fig. 7 and Fig. 8 compiled from old maps and other data by B. Kotō and K. Sekiya, shows the comparative extents, in ancient times and at present, of land in the vicinities of Ōsaka and Nagoya.

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[1] Doubts may be entertained on the authenticity of these old maps, and we cannot vouch for the exact truth of the conclusions.

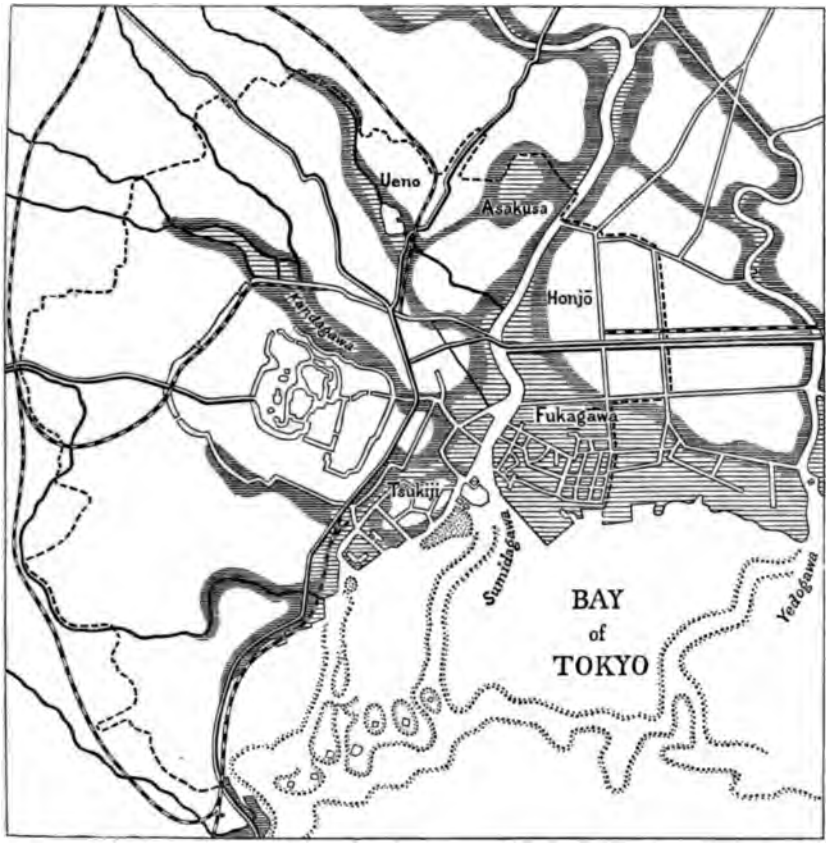

Fig. 5.—Map showing the positions of Tokyo with relation to the bay in the Chōgen epoch (1028–1036) and at the present time. The shaded portion indicates the reclaimed land. (After "Ō-Edo-zusetsu-shūran.")

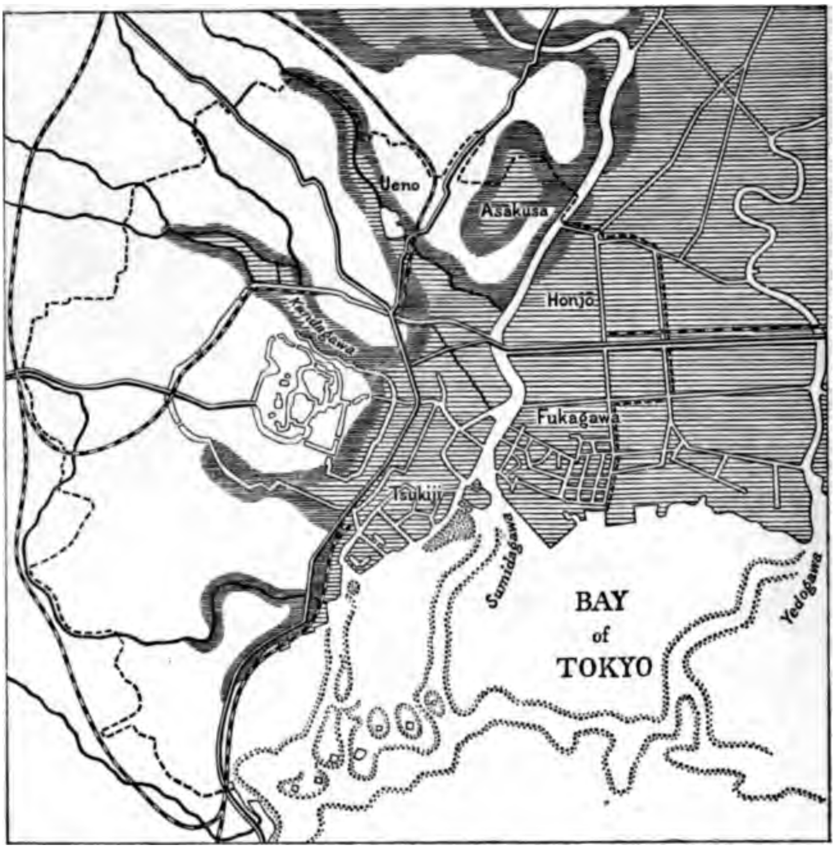

Fig. 6.—Map showing the comparative positions of Tokyo with relation to the bay in the Chōroku Epoch (1457–1459) and at the present time. The shaded portion indicates the reclaimed land. (After "Ō-Edo-zusetsu-shū-ran.")

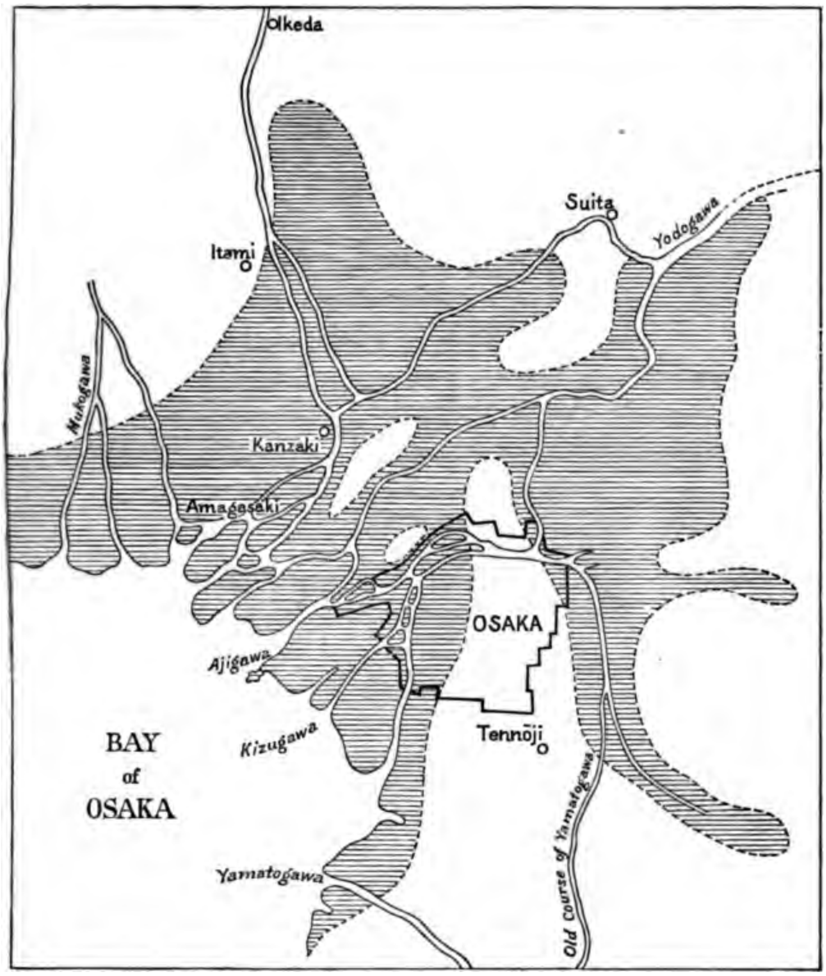

Fig. 7.—Map showing the comparative positions of Ōsaka with respect to the bay, in ancient times and at present. (After Kotō and Sekiya). The shaded portion indicates the reclaimed land.

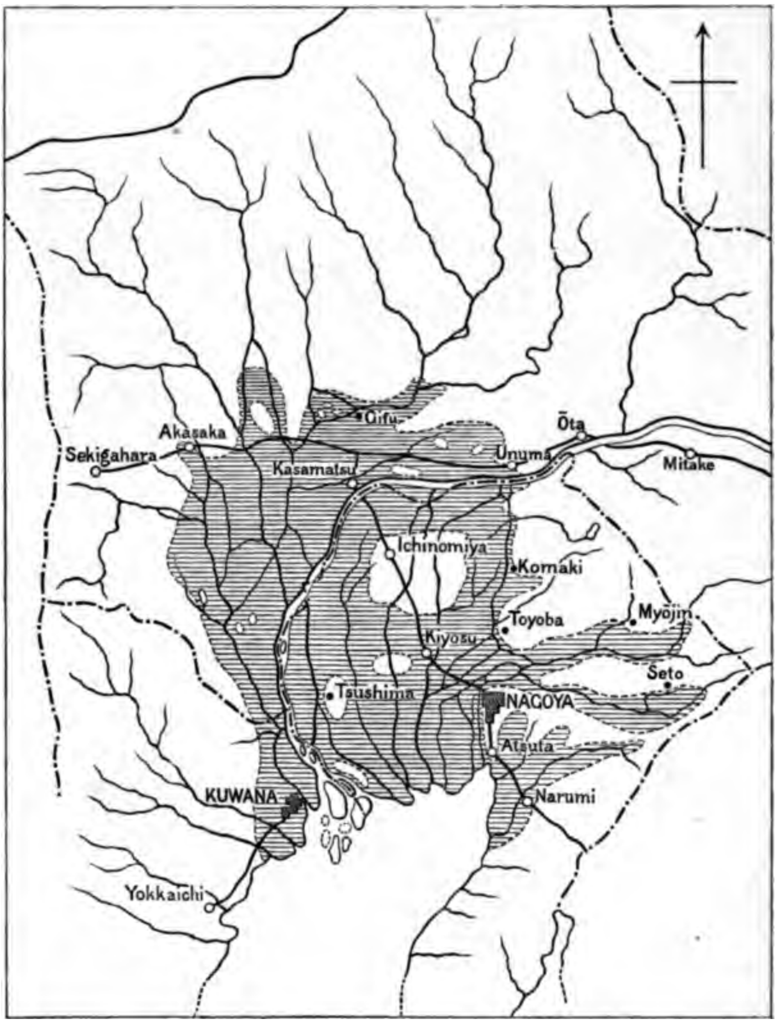

Fig. 8.—Map showing the increase of the area of Alluvium in the Mino-Owari Plain within recent times. Compiled by B. Koto from an old map of more than a thousand years ago and other data. The increase is shown by the shaded portion.

CHAPTER VIII.

IGNEOUS ROCKS.

Igneous rocks have an important place in the structure of the Japanese Islands. They are classified as follows:—

I. *Older Igneous Rocks.*

1. Granites, Quartz-diorites, Quartz-porphyries.
2. Gabbros, Diorites, Peridotites, Serpentines.
3. Diabases, Porphyrites.

II. *Younger Igneous Rocks.*

1. Liparites, Dacites.
2. Andesites, Basalts.

I. OLDER IGNEOUS ROCKS.

Granites. Granites are the most widely extended of alt pre-Tertiary eruptives. Schistose granite constitutes the so-called Gneiss System and has been described in the chapter relating to that system. In the Palæozoic era we have little evidence of the protrusion of granites; but it seems that great irruptions must have taken place in the Mesozoic era. Granite is exposed in wide areas from Hokkaidō to the Ōshima Islands, south of Kyūshū. In Taiwan no occurrence is known, except that granite pebbles have been found in a valley to the north of Karen-kō.

Contact phenomena of granite on Palæozoic clayslatesl have been observed in several places. Cordierite, and sometimes andalusite and chiastolite, are found in clayslates of the provinces of Hitaka, Rikuchū, Shimotsuke, Tamba, etc.

Cordierite from Shimotsuke and Tamba has been described by Y. Kikuchi and designated 'Cerasite'[1]

Granites furnish the best building-stone in Japan. The greatest supply comes from the coasts of the Inland Sea; it is quarried also in Mikawa, Ōmi, Hitachi, etc.

Quartz-diorites. The age of irruption is uncertain in most cases. Structurally the rocks are classed with the older eruptives. But one mass intruding into the Misaka Series seems to belong to the Tertiary; and the rock exposed near Mt. Ishizuchi in Shikoku truncates Tertiary strata and shows transition into liparite and quartz-porphyry.

Quartz-porphyries. They occur forming large masses in the south-eastern part of the Echigo Mountains, in the Nikko region, Hida, Tamba, and Chūgoku, thus being confined to the mountains of the inner zone. Other occurrences are mostly small dykes. The rock often approaches, in composition, granite on one side and liparite on the other. The question of age of eruption remains unsolved in many cases.

Gabbros and Diorites. They occur in widely distributed small areas. Transition into gabbro-diorite is no uncommon occurrence. Norite is found in small patches in Hida, Awaji, Nagato, etc. The typical gabbro and gabbro-diorite of Mineoka-yama in Awa are of Tertiary eruption.

Peridotites and Serpentines. These occur together with gabbros and diorites. The gabbros and serpentines of the Archæan and Palæozoic eruptions are found accompanying crystalline schists and Palæozoic formations; and those widely distributed in Chūgoku seem to belong to a later issue. Northern Hitachi and middle Higo are localities noted for peridotites. Ophicalcite is quarried in the Chichibu district in Musashi.

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[1] Y. Kikuchi, On Cordierite as a Contact Mineral, Journ. Col. Sc.. Vol. III, 1890.

Diabases. Typical diabase is found near Kurumizasu in Chichibu. Thick masses of diabase, found intercalated in the Palæozoic formations, and the great developments of variegated schalsteins which accompany them, bear witness to the mighty eruptions of this rock in the Palæozoic era.

Porphyrites. Porphyrites commonly accompany the diabase and schalstein of the Palæozoic; they also occur as intruding Jurassic rocks in Rikuchū, Hida, Etchū, etc., and accompanying the young schalstein formation of Nagato. The porphyrite found in the Misaka Series is of later eruption, probably of the Tertiary period; it differs lithologically from the older ones and resembles the apo-andesites of the Tertiary.

II. YOUNGER IGNEOUS ROCKS.

All the portions coloured as volcanic rocks in the geological map belong to the eruptives of the Tertiary and Quaternary periods. They comprise Liparites, Dacites, Andesites, and Basalts.

Liparites. The eruption of liparites probably dates from the beginning of the Tertiary period. Their tuffs form thick sediments in many places, and are of especially wide development in Northern Japan. Many of the important metalliferous veins in Northern Japan and Chūgoku are contained in liparites.

Decomposed liparites furnish materials for porcelain manufacture in numerous places, such as Arita in Hizen, Amakusa in Higo, Tobe in Iyo, etc.

The largest exposures of liparites are in Chūgoku; the most of the volcanic rocks appearing in Echizen, Kaga, and Etchū, and a portion of those in the Echigo mountains, are liparites.

Dacites. They are exposed in limited areas. In Chūgoku some portions of the liparites contain abundant plagioclase as well as orthoclase in a dark gray ground-mass, and this makes a sharp division between the two rocks of dacite and liparite sometimes difficult. Jōzankei in Ishikari, Arai in Izu, etc., produce a beautiful porphyritic variety with nevadite structure.

Andesites.—Of andesites, including mica-andesites, hornblende-andesites, and pyroxene-andesites, the last mentioned has the widest distribution. Many subvarieties of pyroxene-andesite occur, such as augite-andesite, enstatite-andesite, bronzite-andesite, hypersthene-andesite, olivin-bearing-pyroxene-andesite, etc.

Andesites have been extensively erupted since the Tertiary period. Of all volcanics they have the widest distribution on he Japanese Islands and they compose all of the active volcanoes. They are accompanied in most cases by great deposits of tuffs, agglomerate-tuffs, and lava-breccias, and sometimes they form interstratified sheets in a series of sedimentaries. Some of the older andesites have suffered metamorphism by mineral waters and gases and are known as apo-andesite. Andesites are very widely used as buildingstone.

Basalts.—Typical basalt with augite of a brownish-violet tinge occurs in Chūgoku and Northern Kyūshū. It forms outcrops of small area, as simple domes, and as sheets and dykes. Another variety commonly classed as basalt might be called basaltic andesite; it is essentially augite-andesite containing abundant olivin, usually dark gray or black and showing pheno-crysts of plagioclase and olivin. It occurs in large volcanoes together with ordinary augite-andesite.

The form and structure of volcanoes depend greatly on the character of their constituent rocks. Basalt forms small isolated domes of the simplest type, such as Kannabe-yama in Tajima and Tagura-yama in Tamba. Acidic andesites like mica-andesite and bronzite-andesite form also small simple cones as seen in Kabuto-yama in Settsu and Iino-yama in

Sanuki. But large volcanoes are mostly built of andesites of intermediate and basic compositions; they are simple-coned as Fuji and Kaimon, double-coned as Asama and Norikura, or more complex as Aso and Hakone; or they may form crater lakes as Osore-zan Lake in Mutsu and Unagi Lake in Satsuma, or crater-harbours as Hafu Harbour of Ōshima Island of Izu.

Volcanoes are most abundant in the Chishima Islands, Hokkaidō, Northern Japan, Kyūshū, and the Ōshima Islands. The regions of the Akaishi and Kiso Mountains, Kii and Shikoku contain very few volcanoes. No volcanoes, except the group of Taiton-zan, are known in the Island of Taiwan. It has been briefly mentioned in the topographical chapter that the numerous volcanoes of Japan can be grouped into a number of volcanic lines. The most conspicuous is the Fuji Volcanic Zone, which passing nearly on the boundary of Northern and Southern Japan, continues in the Pacific Ocean through the Shichi-tō, the west of the Bonin Islands, and the Volcano Islands. The volcanic zones of Nasu, Chokai, and that of Chishima, which is connected with the volcanoes of Kamtchatka, continue through the northern half of the Japanese Empire. The volcanic groups in the south are: the chain of Norikura with the volcanoes of Tateyama, Norikura, and Ontake, the Hakusan Zone with the volcanoes on the coast of the Sea of Japan, Aso Zone including the Aso and Unzen groups and the Kirishima Volcanic Zone, stretching between southern Kyūshū and the northern extremity of Taiwan.

The number of volcanoes (independent cones and groups) already known is 165. Among them the active volcanoes number 54.

The volcanoes now known are as follows: the active volcanoes are indicated by * .

Chishima Islands.

- * Alaid-jima.
- * Masakariyama, paramoshiri-jima.
- * Fuss-peak, „
- * Shirinki-jima.
- Makanrushi-jima.
- Nemoyama, Onnekotan-jima.
- * Kuroishi-yama, „
- * Harimkotan-jima.
- * North-peak, Shashikotan-jima.
- South-peak, „
- * Ekarma-jima.
- * Chirinkotan-jima.
- * Raikoke-jima.
- * Matsua-jima.
- Rashua-jima.
- Ushishiri-jima.
- Ketoi-jima.
- Broughton-wan, Shinshiri-jima.
- Chūōbō or Prevost peak, „
- Shinshiri-dake, Shinshiri-jima.
- * Kita-Chirnoi-jima or Chirinoi.
- Minami-Chirnoi-jima or Brat Chirnoef.
- * Suribachi-yama, Urup-jima.
- * Moyoro-dake, Etorofu-jima.
- * Chirip-nupuri, „
- Shashonshi, „
- Rebunshiri, „
- Hechira-nupuri, „
- Shitokap-dake, „
- Atosa-nobori, „
- Peretarabets-dake, „
- Rurui-dake, Kunashiri-jima.
- Chacha-nobori, „
- Rausu-dake, „
- Tomari-yama, „

Main Island of Hokkaidō.

- * Raushi-dake, Nemuro.
- Mashi-yama, „
- Atosa-nobori, Kushiro.
- Oakan-dake, „
- * Meakan group, „
- Nutapkaushpe, Ishikari.
- Optateshke, Tokachi.
- Tokachi-dake, „
- Rishiri-jima.
- Nisekoan-nupuri, Shiribeshi.
- Makkari-nupuri, Shiribeshi.
- Eeniwa-dake, Iburi.
- Shiripets-dake, „
- * Tarumai-dake, „
- Noboribets-dake, „
- Usu-dake, „
- * Komagatake, Oshima.
- * Esan, „
- * Ō-shima, „
- Ko-jima, „

Northern Honshū.

- * Kampū-zan, Ugo.
- Shin-zan, „
- Yone-yama, Echigo.
- * Iwaki-san, Mutsu.
- * Chōkai-zan, Ugo.
- Gassan, Uzen.

Sumon-dake, Echigo.
Asakusayama, Iwashiro.
Kenashi group, Shinano.
Naeba-yama, „
Kasabotchi-yama, „
Shirane-zan (Kusatsu), „
* Asama-yama, „
* Osore-zan or Kamafuse-yama, Mutsu.
Yatsukōda-yama, Mutsu.
Herai-dake, „
Nanashigure-yama, „
Moriyoshi-yama, Ugo,
Yake-yama, „
* Iwate-san, Rikuchū.
Komaga-take, „
Yakeishi-yama „
Kurikoma-yama or Komaga-take, Rikuzen-Rikuchū.
Gatanuma-yama, Rikuzen.
Nenoshiroishi-dake, „
* Zaō-san (Zoō-san), „
* Azuma-yama, Iwashiro.
* Adatarō-yama, „
* Bandai-san, „
Nekoma-yama, „
Hakase-yama, „
* Nasu-yama, Shimotsuke.
Takahara-yama, „
Hiuchi-dake, Iwashiro.
* Shirane-zan, Shimotsuke.
Nantai-zan, „
Hotaka-san, Kōzuke.
Akagi-san, „
Komochi-yama „
Onoko-yama, „
Haruna-san, „
Yake-yama, Echigo.
Myōkō zan, „
Kurohime-yama, Shinano.
Iitsuna-yama, „
Tateshina-yama, „
Yatsuga-take, „
Kayaga-take group, Kai.
* Fuji-san, Suruga.
Ashitaka-yama, „
Hakone group, Sagami.
* Amagi group, Izu.
* Mihara-yama, Ōshima, „
* Oyama, Miyake-jima, „
* Mikura-jima, „
Nishi-yama, Hachijō-jima, „
Mihara-yama, „ „
* Aoga-shima, „
Mitsugo-jima, „
* Kita Iō-jima, „
Iō-jima, „
Minami Iō-jima, „

Southern Honshū.

* Tate-yama, Etchū.
Washiba-dake, Etchū-Shinano.
Kasaga-take, Hida.
Yake-yama, „
Iō-ga-take, Hida-Shinano.
Norikura-ga-take, Hida.
Ontake, Hida-Shinano.
* Haku-san, Kaga.
Dainichi-dake, „
Aoba-yama, Tamba.
Tagura-yama, „
Ōoka-yama, Tajima.
Kannabe-yama, Tamba.
Kasumigasen, Tajima.
Sugenosen, „
Daisen, Hōki.
* Sambe-yama, Iwami.
Kasa-yama, Nagato.

;* (20 cones. [illegible])

Kyūshū ‸ and Ryūkyū.

\ Futago-yama, Bungo.
\ * Tsurumi-dake, „
\ Yubu-dake, „
\ * Kujū-san, „
/40 \ * Aso-san, Higo.
\ Kimbō-san, „
\ Tara-dake, Hizen.
\ * Unzen-dake, „
\ Yahazu-yama, Higo.
\ * Kirishima-yama, Hyūga.
\ Hikono-take, Satsuma.
Katajō-yama, „
/48 Naka-dake. „ Noka on map.
\ * Sakura-jima, Ōsumi.
Noma-dake, Satsuma.
Ōno-dake, Satsuma,
Unagiga-ike, „
* Kaimon-dake, „ —— Ids. [illegible]
* Iō-jima, „
Kuchinoerabu-jima, Ōsumi.
Kuchino-shima, Satsuma.
* Nakano-shima, „
Gwaja-shima, „
* Suwanose-jima, „
Akuseki-jima, „
Takara-jima, „
Yokoate-shima, „
* Tori-shima, Ōsumi.
Kume-jima, Ryūkyū.

Taiwan.

Daiton-zan.

PART III.

ECONOMIC GEOLOGY.

CHAPTER IX.

METALLIFEROUS DEPOSITS.

Metalliferous deposits are treated in the following order:

1. Gold mines.
2. Placer gold.
3. Gold and silver mines.
4. Gold, silver and copper mines.
5. Gold and copper mines.
6. Silver mines.
7. Silver and copper mines.
8. Silver and lead mines.
9. Silver, copper and lead mines.
10. Copper mines.
11. Iron mines.
12. Iron sand.
13. Tin mines.
14. Stream tin.
15. Antimony mines.
16. Manganese mines.

When two or more metals are found in one mine, the classification of the mine is determined by the metal or metals whose value exceeds one-tenth of the total value of the output of the mine. For instance, the Aikawa Mine yields gold, silver and copper, but is classed here as a gold and silver mine because the yield of copper alone does not exceed in value one-tenth of the total production of the mine.

In each category of mines, the descriptions begin with the mines farthest north.

I. GOLD MINES.

Hashidate Mine.—The Hashidate Mine is situated in Aomi-mura, Nishi-Kubiki-gōri, Echigo Province, 3 *ri* south-west of Itoigawa which is the chief town in the district.

The mine was opened about five years ago and we have not yet precise knowledge of its geology. It is said that the gold is mainly contained in quartz veins in Palaeozoic rocks, and is found also in impregnations in the country rock, making very thick auriferous deposits.

Yield of gold, silver and copper from the Hashidate Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	6,286	—	—
1897	10,236	—	—
1898	13,178	227	—
1899	18,011	—	—
1900	18,890	326	2,497

Hō Mine.—This mine is situated in Tsugawa-mura, Minami-Koma-gōri, Kai Province.

The date of discovery is not recorded but the mine has been actively worked since 1681.

A few metalliferous quartz veins containing native gold are here found in Palaeozoic clayslate and sandstone. One principal vein runs east and west, and has a breadth of 2 feet.

Yield of gold and silver from the Hō Mine in 1896.

	Momme.
Gold	2,438
Silver	589

Kanahira Mine.—This mine is situated in Kananomura, Nomi-gōri, Kaga Province.

The mine is said to have been discovered about 200 years ago. Since 1854 its yield has gradually increased.

Numerous metalliferous veins here occur traversing liparite. The thickness of the veins is generally 4 or 5 inches, but is sometimes as much as 3 or 4 feet. The veins consist of barite and quartz, containing native gold associated with zinc blende and iron pyrites.

Yield of gold from the Kanahira Mine.

	Momme.
1896	2,290
1897	7,357
1898	6,326
1899	7,255
1900	5,287

The Hoshino Mines.—The mining district thus designated is in Hoshino-mura, Yame-gōri, Chikugo Province. It lies about 5 *ri* east of the town of Fukushima and 6 *ri* distant from Hainuzuka railway-station. There are several gold mines here worked in a primitive way, and we include this group of mines under the name of the Hoshino Mines.

The quartz veins are in augite-andesite, protruding through the Palaeozoic formation. They are impregnated with iron sulphide or rarely with zinc blende and contain a small quantity of gold and silver. The veins generally strike E.S.E. and are 10 to 20 feet thick.

The most productive of these mines are those known respectively as the Komuro mine and the Yano mine. The total yield of gold in 1899 was 10,897 *momme.*

Serigano Mine.—The Serigano Mine is in Kushiginomura, Hioki-gōri, Satsuma Province and is conveniently situated, being adjacent to the highway leading to Kagoshima, the principal city in Satsuma, and about 10 *ri* north of that place.

The mine was discovered in 1652 and opened in 1658. Since that time, it has been continuously worked, though it has never been very productive.

Augite-andesite constitutes the country rock in this vicinity, and it is traversed by numerous metaliferous veins of which those known as the Yagi-bi, Umenoki-bi, Uba-bi, and Mukoda-bi are the principal ones worked. These veins run in general N.E. and dip S.E. The thickness of the veins varies from a few inches to 9 feet.

The veinstone consists of quartz containing gold, silver, and small quantities of iron pyrites and chalcopyrite.

The following analyses show the percentage of gold and silver in the principal veins:

		Gold.	Silver.
Yagi-bi		0.006	0.0046
Umenoki-bi	(1)	0.006	0.0130
	(2)	trace	0.0030
Uba-bi	(1)	0.009	—
	(2)	0.005	—
Mukoda-bi	(1)	trace	0.0350
	(2)	trace	0.0140
	(3)	0.007	0.0644
	(4)	0.226	0.6440 (The best ore ever found in this lode.)

Yield of gold and silver from the Serigano Mine.

	Gold. Momme.	Silver. Momme.
1896	3,711	—
1897	3,326	—
1898	3,568	8,327
1899	3,313	7,730
1900	3,073	7,171

Yamagano Mine.—The Yamagano Mine covers a wide area on the boundary between Satsuma and Ōsumi, and is located only 2 *ri* to the west of Yokogawa on the highway leading from Ōsumi to Higo Province. It lies 7 *ri* to the north of Kajiki, the chief town of Ōsumi, and 12 *ri* to the north of Kagoshima.

The mine was discovered in 1640 and opened in the next year. In 1659 it was highly productive, yielding 498,000 *momme* of gold, but after that time the output gradually declined, so that at some periods the work was almost abandoned. Of late new methods of mining have been introduced under the management of the House of Shimazu, former lords of Satsuma, and this is at present the most promising gold mine in our country.

The district consists of sandstone and shale of the Tertiary period, pierced by augite-andesite. This andesite is traversed by numerous metalliferous veins, and the principal workings are in eight of these, namely, the Nishihama-bi, Gomotsu-bi, Senshyū-bi, Bokunyū-bi, Shinza-bi, Takatsuka-bi, Hairo-bi and Sarashi-bi. These veins may be divided into two groups. One series consists of very thin quartz veins varying from 1 inch to 5 inches in thickness, and crossing each other, the intersections being specially rich in ore. Another type is represented by a quartz vein varying in thickness from 20 to 30 feet with abundant cavities. Near the veins there generally occurs a white clayey substance, such as is produced by fumarole action. The general strike of the veins is east and west, dipping to the north at a high angle.

The veinstone is mainly quartz, often mixed with iron pyrites and calcite. The ore is native gold associated with argentite and rarely with chalcopyrite. The average percentage of gold and silver is 0.005 % and 0.001 % respectively.

Yield of gold and silver from the Yamagano Mine.

	Gold. Momme.	Silver. Momme.
1896	21,247	—
1897	21,733	—
1898	19,102	12,730
1899	18,172	18,403
1900	18,547	15,521

Kago Mine.—The Kago Mine is situated in Higashi-Minamikata-mura, Kawanabe-gōri, Satsuma Province, and is about 13 *ri* distant to the south of Kagoshima. It is said to have been discovered in 1683.

This district is formed of the Mesozoic clayslate and sandstone, with intrusive quartz-porphyry and andesite dykes, which are only met with in excavations, not appearing at the surface. All these rocks are overlaid by thick deposits of pumice-like volcanic ash of the Diluvial epoch. Numerous quartz veins containing gold and silver traverse the country rock in every direction, but never penetrate into the ash, so that the latter is locally called *akuseki* (bad stone). There are three principal veins named respectively the Hon-bi, Takenaga-bi and Abara-bi. All these viens run northeast; and their thickness varies from 2 to 6 feet.

The veinstone consists of quartz and clay. The ore yields about 0.005 % of gold and 0.002 % of silver.

Yield of gold and silver from the Kago Mine.

	Gold. Momme.	Silver. Momme.
1896	6,001	—
1897	5,113	—
1898	3,214	1,892
1899	6,391	—

Kinkwaseki Mine.—This mine is located at Kinkwaseki-zan in the northeastern part of Kiirun-chō, Taiwan and about 3 *ri* west of Kiirun.

It was formerly worked by the Chinese Government before the annexation of Taiwan to Japan. It is now in the hands of the Tanaka Company.

The district is formed of Tertiary sandstone and shale, intersected by a large dyke of quartz-andesite which runs north and south. The metalliferous vein occurs along the eastern side of the dyke, and sends out several branches into the dyke. The thickness of the vein is not less than 20 feet.

The veinstone is reddish clay containing large quantities of gold. The average percentage of gold and silver is 0.0065 % and 0.0018 % respectively.

Yield of gold from the Kinkwaseki Mine.

	Momme.
1899	18,003

Zuihō Mine.—This mine is at Kyūfun-zan in the Zuihō district of Kiirun-chō, and is about 1 *ri* west of the Kinkwaseki Mine.

The rocks are Tertiary sandstone and shale, and are traversed by several metalliferous veins. The largest vein is known to be 2500 feet long and generally 2 or 3 feet in thickness, though in some places it is as much as 7 feet. It strikes north and south, somewhat curving to the west.

The veinstone consists of grayish and whitish clay mixed with quartz which seems to increase downwards. The ore yields 0.0013 % of gold and 0.0006 % of silver.

Yield of gold from the Zuihō Mine.

	Momme.
1899	13,927

II. PLACER GOLD.

The placer gold in Japan mostly comes from the disintegration of quartz veins in volcanic rocks, in the Palæozoic, Mesozoic, and Tertiary formations. The most celebrated locality is Esashi in Hokkaidō, the Klondyke of Japan. In 1899 there were collected 119,082 *momme* of gold according to the official returns and there a gold nugget weighing 198 *momme* was picked up. The place is still actively worked. The sources of the placer deposit of Esashi are quartz veins in the Palaeozoic formation. In Ishikari and Hidaka placer gold is often associated with platinum and iridosmium.

The chief localities of placer gold are as follows:—

HOKKAIDŌ.

Esashi, Esashi-gōri, Kitami.
Rebun, Esashi-gōri, Kitami.
Haporo, Tomamae-gōri, Teshio.
Coast of Teshiro-gōri and Tomamae-gōri, Teshiro.
Sopchi-gawa, Kabato-gōri, Ishikari.
Sorachi-gawa, Sorachi-gōri, Ishikari.
Yūbari-gawa, Yūbari-gōri, Ishikari.
Saru-gawa, Saru-gōri, Hidaka.
Niikap-gawa, Niikap-gōri, Hidaka.
Coast of Hidaka.
Coast of Yamakoshi-gōri, Iburi.
Toshibets, Setana-gōri, Shiribeshi.
Shirinai, Kamiiso-gōri, Oshima.
Esan, Kameta-gōri, Oshima.

HONSHŪ.

Kanazawa-gawa, Kami-Hei-gōri, Rikuchū.
Setamai-gawa, Kesen-gōri, Rikuzen.
Koizumi-gawa, Motoyoshi-gōri, Rikuzen.
Tateya-gawa, Higashi-Tagawa-gōri, Uzen.
Takane-gawa, Iwafune-gōri, Echigo.
Daigo-mura, Kuji-gōri, Hitachi.

Shirakawa Valley, Ōno-gōri, Hida.
Haya-kawa, Abe-gōri, Suruga.

SHIKOKU.

Yoshino-gawa, Awa.

KYŪSHŪ.

Takase-gawa, Hida-gōri, Bungo.

TAIWAN.

Kiirun-gawa, Kiirun-chō.

III. GOLD AND SILVER MINES.

Ponshikaribets Mine.—The Ponshikaribets Mine is situated beside the Shikaribets in the western part of Yoichi-gōri, Shiribeshi Province, and is about 3 *ri* south of the town of Yoichi.

It was discovered in 1891 and opened in the next year.

The terrane about the mine consists of a thick bed of Tertiary tuff, often intersected by andesite dykes. There are three principal veins that run almost parallel to each other and dip to S.S.W. with angles varying from 60° to 70°. The greatest width of any vein is 30 feet and the least 5 inches.

The veinstones are rhodocrosite and quartz, accompanying clay. The ores are auriferous argentite, galena, chalcopyrite and zinc blende.

Yield of gold, silver and lead from the Ponshikaribets Mine.

	Gold. Momme.	Silver. Momme.	Lead. Kin.
1898	11,188	1,196,109	—
1899	936,243	127,220	30,680
1900	9,578	888,357	—

Matsuoka Mine.—The Matsuoka Mine is situated in Yamada-mura, Okachi-gōri, Ugo Province.

The deposit occurs in the contact zone of liparite with the Tertiary strata, and is in the form of stockwork. The ores are argentiferous galena, zinc blende and iron pyrites, mixed with gold. A dark grayish clay exposed on the surface is especially rich in silver.

Yield of gold and silver from the Matsuoka Mine.

	Gold. Momme.	Silver. Momme.
1898	229	59,491
1899	151	75,449
1900	414	27,186

Handa Mine.—This mine is situated at the foot of Handa-yama, in the Handa-mura, Date-gōri, Iwashiro Province, about a half *ri* west of Kōri railway station.

There is no authentic record of the discovery of the mine, but it is said that it was opened about 1000 years ago. At the beginning of 18th century the mine was transferred to the direct management of the Tokugawa Government and was worked continuously for about a hundred years. In 1864, the late Tomoatsu Godai, father of the present owner, reopened the mine and after much hard work succeeded in discovering a vein 5 feet in thickness filled with rich ores. Since then various improvements have been introduced and the mine is now one of the celebrated silver mines of Japan.

Numerous veins pass through the Tertiary and liparite. They dip generally to the west at an angle of 40° to 70°. One principal vein branches at the Saikō adit-level into three veins the Honmyaku, Kameoka, and Dōshiki. The veins vary in thickness from 3 feet to 10 feet.

The veinstone is chiefly quartz with calcite and amethyst. The ore is mostly auriferous argentite associated with more or less zinc blende. Galena, chalcopyrite, iron pyrites and native silver are sometimes found in small quantities.

Yield of gold and silver from the Handa Mine.

	Gold. Momme.	Silver. Momme.
1896	4,378	351,555
1897	4,339	348,415
1898	4,082	396,890
1899	4,510	379,622
1900	6,160	444,454

Takadama Mine.—The Takadama Mine is situated in the Takadama-mura, Adachi-gōri, Iwashiro Province, 1 *ri* from Atami station.

The mine is said to have been discovered in the beginning of the 9th century and it was actively worked during the years 1600–1670. Since 1884 it has been worked with improved methods.

The country rocks are liparite and the Tertiary strata. Numerous veins traverse the liparite and run almost parallel to each other, generally dipping N.N.W. The thickness of the veins sometimes reaches 5 feet, but is generally less.

The veinstone consists of quartz and clay. The latter is found in both hanging walls and foot walls, often containing ores rich in gold. The ore is auriferous argentite and the richest of it contains native gold.

Yield of gold and silver from the Takadama Mine.

	Gold. Momme.	Silver. Momme.
1897	120	11,890
1899	310	20,383
1900	430	21,085

Aikawa Mine.—This mine is situated near the town of Aikawa, Sawada-gōri, Sado Province.

The mine was discovered in 1600 by a merchant of Echigo. After that time, though the mine brought to its proprietors several turns of fortune, the production of gold and silver was so enormous that the name "Sado" became synonymous with gold. After the Restoration of Meiji (1869) the mine was worked by the Imperial Government on an enlarged scale under the direction of foreign engineers. In 1889 it was transferred to the Imperial Household and great improvements in various departments were made. In 1895 it came into the possession of the Mitsubishi Company, the present owners.

The metalliferous veins intersect tuffs and shales of the Tertiary period and augite-andesite. There are three principal veins which run almost parallel to each other, coursing from east to west. The veins that are found north of Hizarisawa dip steeply toward the south and those south of that place dip toward the north. The Tertiary strata strike from N.E. to S.W., forming an anticline at Hizarisawa. Hence it will be easily seen that the deposits are fissure veins along the north and south of the anticline. The Aoban, the southernmost of these three veins, is nearly 100 feet through in the thickest part and a little more than 1 foot in the thinnest. It dips 68° N. The Torigoe vein, the northern-most, has a thickness varying from 5 feet to 50 feet and dips 85° S.; the Ōtate, the middle one, has a thickness of 2 to 10 feet and dips 80° S. The length of the outcrop of the Aoban and Torigoe veins measures about 4000 feet each and that of the Ōtate vein about 2500 feet.

The veinstone is mainly quartz with calcite, rarely with dolomite and gypsum. Though there are great variations in thickness of veins and qualities of ores, the Aoban vein is generally rich in gold and silver, and less variable in thickness; the ores of the Ōtate vein are of a good quality but it is rather variable in thickness; aud those of the Torigoe vein are most changeable in their quality. The ores are chiefly native gold and silver, and argentite associated with chalcopyrite, iron pyrites, zinc blende and galena, rarely stephanite, pyrargyrite, marcasite, arsenopyrite.

Yield of gold, silver aud copper from the Aikawa Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	63,844	1,234,475	—
1897	53,858	744,366	—
1898	52,295	744,950	48,976
1899	52,275	856,047	38,360
1900	58,020	981,538	54,963

Kuratani Mine.—The Kuratani Mine is situated in Saikawa-mura of Ishikawa-gōri, Kaga Province, 6 *ri* south of the city of Kanazawa.

It is said that the mine was first opened about 300 years ago by Lord Niwa, of Komatsu; and afterward it was enlarged under the management of the House of Maeda, lords of Kanazawa. From 1716 to 1870 the mine was abandoned. In 1877 it was reopened and since 1893 it has been worked by the Kuratani Mining Company, with greatly improved mining and metallurgical methods.

The rocks of this district consist of Tertiary tuffs and liparite. Clay veins, having generally a thickness of 2 or 3 feet, lie in the Tertiary tuffs near the contact with liparite. One principal vein strikes N.N.E.-S.S.W. and dips 70°-80° E.S.E.

The veinstone is rhodochrosite, sometimes associated with barite, calcite, and feather-ore. The ores are chiefly argentiferous galena with zinc blende and iron pyrites, and they contain gold.

Yield of gold, silver and lead from the Kuratani Mine.

	Gold. Momme.	Silver. Momme.	Lead. Kin.
1896	7,145	—	103,299
1897	12,931	—	221,678
1898	14,993	—	227,500
1899	15,578	259,889	231,500
1900	18,196	288,939	—

Kōsen Mine.—The Kōsen Mine is situated in Migumi-gōri, Tajima Province, 4 *ri* northwest of Toyooka, the chief town in Tajima.

The rock consists of granite, traversed by propylite dykes. Two principal mineral veins are found in granite, running almost north and south with a dip of 45° E., and they have a close relation to the propylite dykes.

The veinstones are chiefly quartz mixed with iron pyrites and galena. The ore is argentite, sometimes with native gold which is recognizable by the naked eye.

IV. GOLD, SILVER AND COPPER MINES.

The Ikuno Mines.—These famous mines are situated near the town of Ikuno, Asa-gōri, Tajima Province, the name embracing several mines in that vicinity. The Ban-Tan Railway passes through the town, connecting with the San-yō Railway at Himeji. Transportation by sea is chiefly from Shikama located 1 *ri* south of Himeji. The Ikuno Mines have been extensively worked and have long been as famous as the Aikawa Mine in Sado.

The mines are said to have been discovered in 807, but it was not until 1542 that they were worked by a somewhat advanced method of mining. During the years from 1596 to 1620 they were extensively worked under the management of the Tokugawa Government. In 1868 they passed into the possession of the Imperial Government and all the old mining methods were replaced by new ones, so that the yield suddenly increased. In 1896, together with Aikawa Mine, they were transferred to the Mitsubishi Company and since that time their productiveness has increased still more.

There are three principal mines, namely the Tasei, Kanagase and Kasei.

1. **Tasei Mine.**—This mine is located in the town of Ikuno.

Liparite, propylite and Tertiary tuffs constitute the mother rock of the mine. The principal lode, called Tasei-bi, is 5400 feet long shooting out numerous branches, which are also worked under various names. The average width is 14 feet. The vein strikes due east and west, and dips to the north at an angle of 50°.

The veinstone is quartz mixed with calcite, rhodochrosite, and fragments of the country rocks. The ores are argentite, native gold and silver, with chalcopyrite, iron pyrites, galena, zinc blende and malachite. Besides these is often found a gold ore of brownish color.

2. **Kanagase Mine.**—The Kanagase Mine is situated about a half *ri* west of Tasei.

The country rocks are the same as at Tasei, but are here traversed by basalt dykes. A great fault runs from S.W. to N.W. and the fault seam is filled with breccia caused by the crushing of the rocks. It is 30 to 40 feet wide. Metalliferous veins are more numerous than at Tasei, and six of them, known respectively as the Kanagase, Senju, Wakabayashi, Otobuse, Shirokuchi, and Washiwaka supply the principal workings. The first three are really the same lode more than 10,000 feet in length, running almost N.–S. and dipping 60° E.

The veinstones are chiefly quartz and calcite, containing chalcopyrite, bornite, iron pyrites, fahlore, argentite, galena, stibnite, pyrargyrite, zinc blende, bismuth, and native silver and copper.

3. **Kasei Mine.**—The Kasei Mine is located in Mikobata-mura, Asa-gōri, 4 *ri* northwest of Ikuno.

The district consists of diorite traversed by liparite and propylite dykes. Metalliferous veins are found in the diorite and are often dislocated by the protrusion of dykes. The principal vein, known as the Kasei-bi, is more than 5300 feet in length and at its widest part is nearly 50 feet across. It strikes N.–S. dipping to the east at an angle of 50°.

The veinstone consists chiefly of quartz, sometimes mixed with calcite and rhodochrosite. The ores are argentite, native silver, chalcopyrite, iron pyrites, pyrargyrite, stibnite, galena and zinc blende.

Yield of gold, silver and copper from the Ikuno Mines.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	26,365	851,522	261,996
1897	29,113	869,903	—
1898	24,033	922,870	—
1899	27,071	1,230,279	698,246
1900	29,620	1,260,932	752,943

Ōmori Mine.—The Ōmori Mine is located 1 *ri* south of the town of Ōmori, Nima-gōri, Iwami Province.

The mine was discovered and opened about 600 years ago, but work in it stopped during the series of wars from 1334 to 1525. In 1525 it was reopened and was most productive from 1600 to 1740. After that time the output gradually decreased, the upper part of the deposit being almost exhausted while downwards the ores became poorer.

The rocks of this mine are hypersthene-quartz-andesite, its agglomerate, and the Tertiary strata. The ore deposits are naturally divided into two groups, the Eikyū and the Hontani.

The deposit of the Eikyū group lies in hypersthene-quartz-andesite. The best of the ores is found in veinstone consisting of iron pyrites and quartz, and the vein attains a thickness of one or two feet. It strikes nearly E.–W. and dips to the north at a high angle. It has been worked through a length of 120 feet, and downwards to a depth of about 300 feet, where the working becomes very difficult. The ore is auriferous and argentiferous chalcopyrite.

The Hontani group consists of impregnation deposits occurring in the form of stockwork in agglomeratic hypersthene-quartz-andesite, which is locally called *fukuishi*. Besides these there are found numerous veins commonly associated with *fukuishi*. The ores are native silver, argentite, siderite and malachite.

Yield of gold, silver, copper and lead from the Ōmori Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.	Lead. Kin.
1896	—	515,411	—	—
1897	—	465,536	—	—
1898	2,165	315,951	127,075	—
1899	3,239	144,237	75,576	1,966
1900	2,880	121,280	61,175	—

V. GOLD AND COPPER MINE.

Ōkuzu Mine.—The Ōkuzu Mine is situated in Ōkuzu-mura, Kita-Akita-gōri, Ugo Province, 3½ *ri* southwest of the town of Hanawa.

The mine was discovered in 1604. At present it is one of the celebrated mines of Japan.

The country rocks of the district are Tertiary tuff and augite-andesite. Numerous veins cross the Tertiary, striking N. or N.E. and dipping generally to N.W. at high angles. The thickness of the veins is commonly one foot or much less, but sometimes it is 2 or 3 feet.

The veinstones are the country rocks and clay mixed with quartz. The ores are chalcopyrite associated with iron pyrites and rarely with zinc blende.

Yield of gold, silver and copper from the Ōkuzu Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	2,763	—	17,252
1897	2,610	—	—
1898	1,572	—	—
1899	1,980	90	60,383
1900	1,232	72	42,514

VI. SILVER MINES.

Mizusawa Mine.—The Mizusawa Mine is situated in Sawame-mura, Yamamoto-gōri, Ugo Province.

The deposits lie in a contact zone of Tertiary strata with augite-andesite, or are found in the form of stocks along the dislocated surface of the andesite.

The ore is chiefly "black ore," with some silver ore which is probably stephanite. Occasionally native silver is found. In 1896 this mine produced 156,168 *kwamme* of ore.

Tsubaki Mine.—This mine is situated in Hachimori-mura, Yamamoto-gōri, Ugo Province, 6 *ri* north of the town of Noshiro.

It was opened in 1889 and quickly became a celebrated mine on account of the good quality of its ores and its convenient location.

The country rock is Tertiary shale covered by Diluvial strata, exposed amid black basaltic andesite which appears on both sides of the tract of shale. The deposits of this mine are generally in the form of stockwork, though some true veins occur with a thickness of one to five feet. The shale is often so impregnated by the ores that it may be used as ore.

The ore is the so-called *kuromono* or "black ore," a mixture of barite, argentite, zinc blende, galena, iron pyrites, quartz, calcite, and chalcopyrite. It contains generally 0.07% of silver, but the richer parts yield 0.15%–0.3% of the metal. The deposits in vein form have sometimes a gangue of clay resulting from decomposition of the country rock, and contain rich ores with 0.8%–4.8% of silver.

Yield of silver from the Tsubaki Mine.

	Momme.
1896	454,133
1897	388,886
1898	464,255
1899	469,722
1900	393,907

Hachimori Mine.—The Hachimori Mine is situated in Hachimori-mura, Yamamoto-gōri, Ugo Province.

The deposits are of two kinds, veins and impregnations, both being contained in augite-andesite. The veins generally have a strike E. and W., dipping steeply toward the south. The greatest thickness of the veins is two or three feet.

The ore resembles the "black ore" already mentioned, and consists of argentiferous zinc blende, with galena, rarely with chalcopyrite and barite. The impregnated deposits sometimes contain richer ores than the veins.

Shirayama Mine.—The Shirayama Mine is situated in Kami-Shinjō-mura, Minami-Akita-gōri, Ugo Province.

Numerous veins traverse Tertiary tuff and shale, which are often intersected by augite-andesite. One principal vein has a strike of N. 20° E., steeply dipping towards the west, and a breadth of a few feet. The veinstone is quartz and barite. The ore consists of galena, zinc blende, iron pyrites and chalcopyrite.

The production of silver in 1998 was 21,852 *momme*.

Tagonai Mine.—The Tagonai Mine is situated in Higashi-Naruse-mura, Okachi-gōri, Ugo Province, 6 *ri* south of the town of Yokote, and 4½ *ri* east of Yusawa.

The date of the discovery of the mine is not known, but it is said to have been opened about 200 years ago and it was worked till 1840, when it was abandoned owing to the ignorance of the owners as to drainage and ventilation. In 1886 the mine was reopened and it has become gradually prosperous in consequence of the adoption of new methods of mining and metallurgy.

The rocks are Tertiary tuff, augite-andesite and liparite. The deposits are found as stockwork in liparite or as veins passing through augite-andesite, or sometimes as masses lying under tuff and upon andesite.

Some of the ores are silver ores accompanying iron pyrites which is decomposed to iron oxide; some are barite and quartz containing silver or galena, associated with small quantities of chalcopyrite and zinc blende; and some are zinc blende and barite containing silver.

Yield of silver from the Tagonai Mine.

	Momme.
1896	111,570
1897	190,370
1898	231,997
1899	164,451
1900	49,137

Hata Mine.—The Hata Mine is located in Arakawa-mura, Senhoku-gōri, Ugo Province, about 7½ *ri* S.E. of Akita, the chief city of the province.

The mining district consists of Tertiary brecciated tuff underlaid by shale; and these are pierced by liparite, associated with other tuffs. Ore deposits occur in the form of veins or as impregnations in Tertiary tuff and shale, especially near the contact with liparite.

The veinstone comprises quartz, calcite and barite; and the ores are argentite, galena mixed with iron pyrites, and chalcopyrite.

Yield of silver from the Hata Mine.

	Momme.
1896	305,876
1897	262,065
1898	538,111
1899	271,250
1900	328,452

Innai Mine.—This mine is situated in Innai, Okachi-gōri, Ugo Province, near the southern boundary of that province, 4 *ri* south of Yusawa and 9 *ri* distant from Yokote.

The mine is said to have been discovered in 1596, but little is known about its early history. After various changes of fortune during about 200 years, it came into the possession of Satake, then the feudal lord of Akita. The production of silver gradually increased and in the Tempō Era (1830–1843) the output rose to about 100,000 *momme* monthly, which continued during about 11 years. In 1882, the mine fell into the hands of Ichibei Furukawa, the present owner, who has introduced various improved methods of operation.

The environs of the mine consist of Tertiary and Quarternary rocks, propylite and glassy augite-andesite. Numerous veins are found in propylite, but only three, the Hontate-bi, Gorōjōkō and Ōsawa-dōzan, are remarkable.

The Hontate-bi is the most important and largest vein, situated north of the town of Ginzan. It strikes E.–W. dipping 70°–80° S. The vein branches toward the west into a few small ones, of which the Atsumi-bi and Usumi-bi are important. The thickness of the veins varies from 2 to 20 feet, occasionally reaching 30 feet. The veinstone consists of quartz and rhodochrosite; and the ores are stephanite and argentite with chalcopyrite and pyrargyrite.

The Gorōjōkō is situated north of Sen-zan. It strikes N. 70° W. and dips steeply N.N.E. near the adit, but S.S.W. on the west. The thickness of the vein is from 1 to 4 feet. The veinstone is chiefly quartz containing argentite, stephanite, pyrargyrite, zinc blende, galena, chalcopyrite and iron pyrites.

The Ōsawa-dōzan vein strikes N. 80° E., and dips to the north. The ores are chalcopyrite, galena, and zinc blende.

Beside the above mentioned, a vein south of Sen-zan was formerly worked. Two old adit-levels are found in the north of this district.

Yield of gold and silver from the Innai Mine.

	Gold. Momme.	Silver. Momme.
1896	14,469	3,236,858
1897	21,845	3,532,111
1898	26,927	3,579,761
1899	24,694	3,210,525
1900	22,665	2,886,195

Kuromori Mine.—The Kuromori Mine is situated in Kami-Tozawa-mura, Katta-gōri, Iwaki Province.

One vein traverses liparite, dipping 50°–70° W. It has a breadth of 12 feet in the widest part and 1 foot in the narrowest. The veinstone is quartz, sometimes with amethyst. The ore is argentite associated with zinc blende.

Yield of gold and silver from the Kuromori Mine.

	Gold. Momme.	Silver. Momme.
1898	114	5,765
1899	144	67,629
1900	73	39,191

Karuisawa Mine.—The Karuisawa Mine is situated in

Karuisawa-mura, Ōnuma-gōri, Iwashiro Province, about 6 *ri* southwest of the town of Wakamatsu.

The mine was discovered in 1558. In the Tenshō Era (1573–1591) it was prosperous under the management of Katō, a feudal lord, producing monthly from 30,000 to 40,000 *momme*. About 120 years after, the output of the mine sank to its lowest point. In 1881 it passed into the hands of Ichibei Furukawa, and then the monthly production of the mine was only from 5,000 to 6,000 *momme* of silver. But after improvements had been made in the mining methods the production was greatly increased.

This deposit is characterized by abundant small veins crossing Tertiary tuffs like a network. The strike bends like a bow from N.E. to S.W. The thickness of the veins is quite variable, being in some places 50 or 100 feet, and again thinning out to a few inches.

The ore is argentite associated with more or less iron pyrites and magnetite, and mixed with quartz, barite and calcite.

Akenobe Mine.—The Akenobe Mine is situated in Wada-mura, Yabu-gōri, Tajima Province, about 4½ *ri* northwest of the Kasei Mine at Ikuno.

It is said to have been discovered and opened at the same time as the Kasei Mine, in 1542.

The mining district consists of Palæozoic and Mesozoic formations with intrusive diorite and also pierced by dykes of liparite and quartz-andesite. Several hundreds of veins traverse the country rocks. They were formerly worked for copper very successfully but at present the working is partly stopped. The veins contain silver and copper ores.

Yield of gold and silver in 1900 from the Akenobe Mine.

	Momme.
Gold	42
Silver	147,217

VII. SILVER AND COPPER MINES.

Towada Mine.—The Towada Mine is situated on the western shore of Towada-ko in Nanataki-mura, Kazuno-gōri, Rikuchū Province. Being amidst high mountains, it is very difficult of access.

The mine is said to have been discovered in the Kwambun Era (1661–1672). At present it is owned by the Fujita Company of Ōsaka.

The environs of the mine consist of Tertiary rocks, which in some parts, are covered by volcanic ejecta and Diluvial clay and associated with intrusive augite-andesite. The deposit is a clay vein in Tertiary tuff, the clay being occasionally replaced by gypsum next to the foot-wall. The greatest thickness of the vein is over 100 feet and the least 30 feet. The strike is N. or N.N.E.

The ore found in the clay and gypsum vein is argentite with chalcopyrite, containing small quantities of gold.

Kosaka Mine.—The Kosaka Mine is situated in Kosaka mura, Kazuno-gōri, Rikuchū Province, in a hilly region about 580 feet above the sea-level, 2 *ri* south of the town of Kemanai, 4½ *ri* south of Hanawa and 13 *ri* north of Hirosaki.

In 1862 a peasant discovered silver ores in a rivulet. Four years after, Nambu, a feudal lord, opened the mine and it was worked, till the revolutionary war. In 1870 the government reopened the mine and worked it under the direction of J. Netto, a German engineer. In 1877 the the government leased it to Nambu, former feudal lord, who, after working it about three years, was obliged to return it to the government. Since then the mine has become one of the most profitable in Japan. The Fujita Company bought it in 1886 and introduced further improvements.

The rocks are Tertiary tuff, dipping 30°–40° E., with frequent intrusions of liparite and dacite. The ore deposit lies in the tuff and seems to have a close relation to the dacite, as the whole of it is near the contact of the latter with the tuff. It seems to be an impregnation, forming a large stock. The strike is N.–S., nearly the same with that of the country rocks, steeply dipping toward the east. The thickness is from 100 to 300 feet, thinning out to 20 feet. The length is 2500 feet so far as has been ascertained by boring and excavation. The dipward extent has not yet been ascertained beyond 300 feet from the top of the outcrop.

The ore is the so-called *kuromono* or "black ore," characteristic of northern Japan. The "black ore" consists chiefly of chalcopyrite, iron pyrites, zinc blende, galena and barite, homogeneously combined. Oxidized varieties change to earthy ores consisting of cerussite, azurite, malachite, chalcanthite, native copper, native silver and barite. The latter varieties of the ore naturally decrease downwards.

Yield of gold, silver and copper from the Kosaka Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	—	1,648,702	141,863
1897	—	1,585,484	205,709
1898	—	1,981,797	543,475
1899	353	1,419,117	1,388,250
1900	856	1,059,653	1,655,539

Ōmaki Mine.—The Ōmaki Mine is situated in Nishitate-mura, Kita-Akita-gōri, Ugo Province, 1½ *ri* south of Ōgita and 3 *ri* south of Ōtate.

It is said that about 150 years ago silver ores were first discovered at this place and afterwards copper ores. In 1885 an old pit was reopened and after thorough investigation the deposit was found to be a rich one.

The rocks are Tertiary tuff and andesite. The ore deposit occurs in the form of irregular massive pockets, two of them being large and workable. One of them measured 130 feet in its longer diameter, reaching down about 70 feet obliquely to the north. The roof is covered with jasper, and both the jasper and the argentiferous deposit are enclosed in so-called soap-stone. The ore is reddish oxide of silver with barite. This large pocket, however, has been almost worked out. Another large one, contained in brown tuff, is 150 feet in its longer diameter. The ore is argentite with zinc blende, chalcopyrite, iron pyrites, galena, barite and gypsum.

The production of silver and of copper from the mine in 1896 was 185,260 and 858,316 *momme*, respectively.

Hisanichi Mine.—The Hisanichi Mine is situated in Nakagawa-mura, Senhoku-gōri, Ugo Province.

The rocks are Tertiary strata and augite-andesite. One principal vein has a strike of N. 60°–70° E. with steep inclination toward N.N.W., and a breadth of from one to four feet.

The ore is galena, with chalcopyrite, zinc blende and iron pyrites.

Yield of silver and copper from the Hisanichi Mine.

	Silver.	Copper.
	Momme.	Kin.
1898	10,252	61,340
1899	68,636	517,389
1900	134,074	432,266

Hatasa Mine.—The Hatasa Mine is situated in Hatasa-mura, Gujō-gōri, Mino Province, 5 *ri* north of the town of Hachiman and 19 *ri* north of the city of Gifu.

There is no authentic record of the discovery of the mine, but it was worked, about 300 years ago, by Inaba, feudal lord of Hachiman. In 1600 the mining was done by Endō, then feudal lord of Hachiman, and the mine was highly productive in the Kwambun Era (1661–1672). And in 1880 it was acquired by Kidani, the present owner.

The rocks are quartz-porphyry and andesite. There are four principal veins, three of which contain argentiferous copper and galena and another one carries silver ores. The former three course N.–S. dipping 50°–60° E., while the latter runs E.–W. dipping 50° N. They have a breadth of two feet in the widest part and often thin away to three or four inches. The veins consist of quartz containing argentiferous chalcopyrite, galena, argentite, zinc blende, iron pyrites, etc.

Yield of silver and copper from the Hatasa Mine.

	Silver. Momme.	Copper. Kin.
1898	57,780	14,128
1899	137,338	25,685
1900	165,416	29,505

Waidani Mine.—The Waidani Mine is situated in Kamine-mura, Taka-gōri, Bizen Province. It is 14 *ri* west of the town of Himeji and conveniently situated, being about 1 *ri* distant to the north of Yoshinaga railway station.

The rock which contains the lodes is liparite. The principal lodes are two, the Tensei and the Waidani; the former strikes N.–S. while the latter runs N.N.W. Though the veins contain copper ore of good quality, they are so thin that the mine can not be brought up to any high degree of productiveness.

The ore is argentiferous chalcopyrite associated with zinc blende and galena.

Yoshioka Mine.—The Yoshioka Mine is situated in Fukiya-mura, Kawakami-gōri, Bitchū Province, 17 *ri* northwest of the city of Okayama, in a very inconvenient place surrounded by mountains; though, since it came into the hands of the Mitsubishi Company, a new road has been made from the mine to Yuno on the bank of the Takahashi-gawa, which makes transportation comparatively easy between the mine and Tamashima harbour. The nearest town is Fukiya.

The mine was first opened in the Daidō Era (806–809) and has been continuously worked ever since. It was however not until the property was transferred to the Mitsubishi Company in 1873 that the working was conducted on a large scale and with noteworthy profit.

The rocks are Palæozoic clayslate, sandstone and schalstein traversed by porphyry dykes. The ore deposits are mainly found in the form of veins near the contacts, and lie in both igneous and sedimentary rocks. The principal veins are the Senya, the Funashiki, the Hashirisaki, the Kitakata and the Sasano. The first four of them occur in Palæozoic rocks, and they generally strike E.N.E.–W.S.W. with a dip to N.N.W. The last one lies in porphyry and is proved to be a contact deposit by the presence of contact minerals. Toward the east all the lodes divide into numerous branches and become inferior in quality.

The veinstone is quartz. The ore consists of chalcopyrite, pyrrhotite, iron pyrites, zinc blende and arsenopyrite. The dressed ore yields 9% of copper.

Yield of silver and copper from the Yoshioka Mine.

	Silver. Momme.	Copper. Kin.
1896	—	1,264,609
1897	—	1,172,211
1898	—	1,036,245
1899	—	—
1900	1,722,000	825,455

Sasagatani Mine.—The Sasagatani Mine is located in Hatazako-mura, Kanoashi-gōri, Iwami.

The district is formed of Palæozoic clayslate, sandstone, schalstein, hornstone and limestone, traversed by a large liparite dyke. There are numerous veins which are contact deposits, generally striking E.–W. with a dip of 70° N. The greatest thickness of the veins is about 50 feet. The veinstone consists of quartz and limestone; the latter being often altered to a lustrous amphibole locally known as *kiguchi* which shows the contact origin of the deposit.

The ore is chalcopyrite associated with arsenopyrite, zinc blende and galena, and containing some silver.

Yield of silver and copper from the Sasagatani Mine.

	Silver. Momme.	Copper. Kin.
1898	60,480	188,622
1899	52,758	188,092
1890	62,961	209,475

VIII. SILVER AND LEAD MINES.

Hosokura Mine.—The Hosokura Mine is situated in Uguisuzawa, Kurihara-gōri, Rikuzen Province, about 7 *ri* west of Ishikoshi railway station and about 16 *ri* north of the city of Sendai.

Numerous veins are found in Tertiary tuff which encloses intrusive andesite and propylite. The veins run in irregular directions, some running from N.E. to S.W. and the others crossing them. The thickness of the veins varies from 2 feet to 15 feet. The veinstone consists of calcite, quartz, fluorite and clay. The ore is chiefly argentiferous galena mixed with zinc blende and chalcopyrite. Feather-ore is frequently met with.

Yield of silver, copper and lead from the Hosokura Mine.

	Silver. Momme.	Copper. Kin.	Lead. Kin.
1896	637,681	—	2,160,390
1897	226,604	—	346,152
1898	493,665	—	1,516,510
1899	455,261	—	1,380,351
1900	511,266	1,959	1,550,541

Kamioka Mine.—The Kamioka Mine lies a half *ri* north of Funatsu, Yoshiki-gōri, Hida Province.

The exact date of discovery of this mine is not known, but it is said to have been discovered about 1200 years ago. In the Tenshō Era (1572–1591) the mine was worked under the management of Kanamori, a feudal lord, and the output was considerable. In the Genroku Era (1688–1703) it was transferred to the direct control of the Tokugawa Government. In 1885 it came into the hands of the Mitsui Company. Since that time various points in the method of working have been improved and the production has gradually increased.

The rocks are amphibole-gneiss with limestone and intrusive quartz-porphyry. The deposits are in vein form and they are generally arranged in two directions, one striking N.–S. with a steep inclination toward the east, and another E.–W. with a steep inclination toward the south. The thinnest veins are from one to two feet through, and the thick ones are from 10 to 50 feet. The deposit sometimes occurs in the form of irregular pockets. The veinstone consists of actinolite and epidote, often with calcite, quartz and feldspar. The ore consists of argentiferous galena, chalcopyrite and zinc blende, associated with crysocolla, malachite, iron pyrites, arsenopyrite and bismuth.

Yield of silver, copper and lead from the Kamioka Mine.

	Silver. Momme.	Copper. Kin.	Lead. Kin.
1896	1,602,363	55,512	574,687
1897	1,160,610	61,631	361,083
1898	1,099,671	56,542	738,392
1899	70,360	3,932	662,527
1900	148,670	6,470	537,487

IX. SILVER, COPPER AND LEAD MINES.

Daira Mine.—The Daira Mine is situated in Fujikoto-mura, Yamamoto-gōri, Ugo Province. It was discovered in 1862.

Numerous veins are found in the Tertiary formation and adjacent andesite. They have no fixed strike and dip, frequently crossing each other. The veinstuff is chiefly country rocks or clay, with quartz and rarely calcite. The ores are galena and chalcopyrite associated with zinc blende and iron pyrites.

Yield of silver, copper and lead in 1896 from the Daira Mine.

Silver	1,402 *momme.*
Copper	288 *kin.*
Lead	1,712 „

Mozumi Mine.—The Mozumi Mine is located in Kamioka-mura, Yoshiki-gōri, Hida Province, near the Kamioka Mine.

In the Tenshō Era (1573–1591) Kanamori, a feudal lord, opened and worked the mine together with the Kamioka Mine, but after about 100 years it was abandoned. It was reopened in the Ansei Era (1854–1859), but was not successful. In 1887 the Mitsui Company bought it together with the Kamioka Mine.

The rocks of the mine are nearly the same with those of the Kamioka Mine,—amphibole-gneiss with crystalline limestone. There are numerous veins, also some irregular masses. Two veins that run almost parallel E.–W. and six that run N.–S. are profitably worked. The former are clay veins dipping toward the south at an angle of 50°–80° and having a thickness of 30 feet in the widest part and a length of a few thousand feet. The latter mostly dips toward the west at an angle of 70° but in some places stands vertical. It has for the most part a thickness of about 3 feet, in a few places increasing to 13 feet, and a length of one thousand feet.

The ores are earthy ore, chalcopyrite, galena, crysocolla, cerussite, arsenopyrite, zinc blende, rarely pyromorphite and pyrargyrite.

Yield of silver, copper and lead from the Mozumi Mine.

	Silver. Momme.	Copper. Kin.	Lead. Kin.
1896	497,093	60,524	108,539
1897	486,777	—	84,637
1898	441,347	118,742	237,986
1899	318,519	131,656	254,991
1900	242,218	97,518	266,122

X. COPPER MINES.

A. VEIN DEPOSITS.

The Ani Mines.—The Ani Mines are located near the town of Ani, Kita-Akita-gōri, Ugo Province, on the upper course of the Ōani, a branch of the Noshiro-gawa, and nearly 8 *ri* south of Takanosu railway station. "Ani" is the general appellation of seven mines, called respectively the

Mukōyama, Makizawa, Kosawa, Kayakusa, Sammai, Ichinomata and Ninomata.

The Mukōyama Mine was first discovered about 320 years ago. In 1670 the Kosawa, and 30 years later the Sammai and the Kayakusa were discovered. The other three were all found and opened about 180 years ago. In 1702 the mines were worked by the House of Satake who introduced some improvements and held the property till 1868. In 1871 the mines were transferred to the local government of Akita and afterward to the Imperial government. In 1885 Ichibei Furukawa became the owner.

The rocks in the vicinity of the mines are Tertiary and Quarternary formations, granite, liparite, dacite and augite-andesite. Numerous veins cross the Tertiary and the andesite. Their breadth varies from a mere streak to six or seven feet. The strike of the veins differs according to the locality, and accordingly they may be divided into three groups; those with N.-S. strike in the Kayakusa district, those with E.-W. strike in the Kosawa and Makizawa districts, and those having strikes between the above two in the Sammai and Ichinomata districts. The dip is generally steep or even vertical.

The veinstone is chiefly quartz with calcite. Barite and gypsum are also found. The ore is chalcopyrite associated with iron pyrites. Zinc blende is also found, often in beautiful crystals.

The silver mine of Mukōyama is situated on the west side of the Ani-gawa. The deposits are impregnations in Tertiary tuff. Two workable deposits have a breadth varying from 1 foot to 65 feet.

Yield of gold, silver and copper from the Ani Mines.

	Gold. Momme.	Silver. Momme.	Copper. Kin.
1896	71	283,662	1,769,844
1897	—	—	1,831,175
1898	—	—	1,662,845
1899	734	286	2,011,450
1900	896	379	2,094,582

Arakawa Mine.—The Arakawa Mine is situated in Arakawa-mura, Senhoku-gōri, Ugo Province, about 4 *ri* north-east of Kakunodate, the commercial centre of the district, and 10 *ri* south of the city of Akita.

The mine is said to have been discovered in 1698 by a merchant of Akita and was formerly known by the name of the Ugaizawa Mine. In 1871 it was reopened, and in 1874 it came into the possession of the local government of Akita and was subsequently handed over to the central government. Two years later Segawa bought the mine and introduced great improvements. By diligent effort during about 17 years he succeeded so well that the mine came to be one of the most celebrated copper mines in Japan. In 1896 it passed into the hands of the Mitsubishi Company, which has introduced further improvements.

The environs of the mine consist of Tertiary and Quarternary rocks, propylite, liparite and hornblende-andesite. Numerous metalliferous veins are found in the Tertiary strata and propylite, running almost parallel to each other, the strike being N.E. or N.N.E. The principal veins are known as the Ugaizawa-ōhi, Hyakumeishi-ōhi, Mae-hi, Tōbei-hi, Kanayamasawa-hi, and Yunosawa-hi, among which the first is the largest and most important. The Ugaizawa-ōhi strikes N. 30°–40° E. with a general dip of 60° N.W., though it is sometimes vertical. It is 24 feet in breadth, of which, when rich, one-third is ore, but it sometimes branches into a few small veins. Other veins are generally thin, varying from 5 to 7 feet.

The veinstone is quartz with calcite and barite. The ore is chiefly chalcopyrite associated sometimes with native copper, cuprite, crysocolla, galena, zinc blende, and always with more or less iron pyrites.

Yield of copper from the Arakawa Mine.

	Kin.
1896	705,048
1897	562,429
1898	798,849
1899	1,106,799
1900	1,324,063

Furokura Mine.—The Furokura Mine is situated in the valley of the Akuya-gawa, Kazuno-gōri, Rikuchū Province, 4 *ri* east of town of Kemanai, and about 8½ *ri* west of Sannohe town in Mutsu Province.

The mine was discovered in 1682 and opened in 1765 by Nambu who was feudal lord of the district. The working was stopped from 1794 to 1868.

Numerous clay veins, containing ore, cut the Tertiary strata and andesite. One principal vein has a breadth varying from 1 foot to 7 feet and dips steeply toward the S.E.

The ore is chalcopyrite associated with iron pyrites, hematite, and rarely zinc blende and galena.

Yield of copper from the Furokura Mine.

	Kin.
1896	202,248
1897	297,008
1898	333,536
1899	493,338
1900	469,839

Osaruzawa Mine.—The Osaruzawa Mine is situated in Osaruzawa-mura, Kazuno-gōri, Rikuchū Province. This district is mountainous but the mine is not inconveniently placed, lying only ¼ *ri* west of the town of Hanawa and about 6½ *ri* south of Ōdate railway station in Ugo Province.

The mine was discovered in the beginning of the 8th century. It was worked for gold in 1600, but about 50 years later copper ores were discovered and worked. Though the mine has been under different proprietors and has frequently given trouble by a serious diminution of its yield, yet it has been continuously worked since its discovery. At present it is owned by the Mitsubishi Company and is one of the most celebrated mines in Japan.

The rocks are Tertiary shale and tuff, with intrusive augite-andesite and liparite. Numerous outcrops of veins are found in shale and andesite near Shitasawa. The mining district is conveniently divided into four sections, the northern being called Nishimichi, the southern Tagōri, the eastern Akasawa and the western Motoyama. The veins are numerous, and all of them are similar in quality. The strike is variable, the veins of the Motoyama section and some of the Tagōri have a strike N.-S. or N.N.E., while those of Akasawa strike E.-W., and those of Nishimichi and some of those of Tagōri strike N.E. The breadth of the veins ranges from 5 or 6 inches to 3 or 4 feet and rarely reaches 30 feet.

The veinstones are decomposed country rocks, quartz and small quantities of barite. The ores are chiefly chalcopyrite and bornite, associated with iron pyrites, small quantities of zinc blende, galena and hematite. Sometimes native copper and chalcanthite are found. Native gold is often mixed with the copper ores or found in the salband of quartz veins. Generally speaking, gold is more plentiful in the upper parts of veins and becomes less as the depth increases. The Motoyama and Tagōri districts are celebrated for producing gold.

Yield of gold, silver, copper and lead from the Osaruzawa Mine.

	Gold. Momme.	Silver. Momme.	Copper. Kin.	Lead. Kin.
1896	2,127	—	1,024,706	8,072
1897	—	—	1,017,242	—
1898	1,392	—	1,249,606	—
1899	2,612	316	1,372,624	7,505
1900	2,107	388	1,529,144	2,295

Mizusawa Mine.—The Mizusawa Mine is situated in Iwasaki-mura, Waga-gōri, Rikuchū Province.

Two principal veins are found in the junction of granite and liparite. The strike is N. 60° E. dipping steeply toward N.N.W. The thickness is generally 3 feet. The ore is chiefly chalcopyrite with small quantities of quartz.

Yield of copper from the Mizusawa Mine.

	Kin.
1898	164,509
1899	224,077
1900	152,925

Nagamatsu Mine.—The Nagamatsu Mine is situated in Ōkura-mura, Mogami-gōri, Uzen Province.

The rocks are Tertiary tuff and shale, traversed by andesite dykes. The veins are numerous and generally run parallel to each other, striking N.–S. and dipping steeply to the east. The Oku-bi, the principal vein, has generally a breadth of from six inches to a foot, but sometimes attains a breadth of 2 feet.

The veinstone is chiefly quartz. The ore is chalcopyrite with iron pyrites and a small quantity of zinc blende.

Yield of copper from the Nagamatsu Mine.

	Kin.
1896	244,309
1897	394,654
1898	638,152
1899	617,268
1900	441,637

Kusakura Mine.—The Kusakura Mine is situated in Kusakura-mura, Higashi-Kambara-gōri, Echigo Province.

Four principal veins run almost parallel in Tertiary strata and andesite. The strike is W.N.W. or N.N.W. and the dip is S.W. at a high angle. The thickness is commonly less than one foot, though it sometimes increases to a few feet.

The ores are chalcopyrite and bornite, accompanying iron pyrites, cuprite and galena.

Yield of copper from the Kusakura Mine.

	Kin.
1896	553,225
1897	650,710
1898	454,990
1899	376,878
1900	441,637

Maze Mine.—The Maze Mine is located in the western extremity of Nishi-Kambara-gōri, in the province of Echigo and on the northwestern foot of Yahiko-yama, which consists of Tertiary strata. The mine is conveniently situated near the sea-coast, 2½ *ri* north of Teradomari, a town on the high-way leading from Niigata to Naoyetsu harbour.

The mine was opened in 1688 by Yamatoda, a Niigata man, and extensively worked with the help of the government of that time. In 1820 it was transferred to Iwashita, and continuously worked till 1884 by his successors, though in 1868 the work was necessarily stopped for a short interval owing to the war of the Restoration. It is said that when the mine was at its best, between 1827 and 1840, it produced annually about 15,000 *kin* of copper. At present it is actively worked and is owned by Yoshida of Niigata.

The rocks of this district are of the Tertiary formation consisting of dark gray shale and liparite-tuff. There frequently occur sheets of agglomeratic lava and propylite dykes, both containing fragments of Tertiary sedimentaries. The metalliferous veins lie in the volcanic rocks, especially in the propylite, generally striking N.E. and dipping S.E. at high angles. There are also found several secondary veins intersecting the main deposits, the places of junction being usually rich in ores. The thickness of the veins is generally small, rarely over 1 foot.

The veinstone is chiefly calcite mixed with quartz. The ore is chalcopyrite associated with iron pyrites, sometimes with zinc blende and galena. There are often found beautiful crystals of calcite in the form of hexagonal scalenohedra, and also amethyst occurring in druse. The dressed ore yields 17.8%–20% of copper.

Yield of copper from the Maze Mine.

	Kin.
1897	114,318
1898	107,125
1899	95,324
1900	84,414

Ashio Mine.—The Ashio Mine is situated near the town of Ashio, Kami-Tsuga-gōri, Shimotsuke Province, surrounded by lofty mountains. There are two roads by which transportation is carried on. One leads to the Nikkō Station 7 *ri* east of the mine and the other to Ōmama Station 10 *ri* south.

The mine was discovered by an inhabitant of the vicinity in 1610, after which it was worked under the direct control of the Tokugawa government. During that time refined copper was used in the building of the Nikkō, Shiba and Uyeno shrines and also of Yedo castle. The yearly production between 1676 and 1688 was 2,320,300 *kin* which exceeded the home demand, so that the greater part of the output was exported to Holland. After the Restoration of Meiji (1868) the mine was transferred to the Nikkō prefectural government of that time, and in 1871 to a private company. In 1877 it came into the possession of Ichibei Furukawa, the present owner, the mine being then in so poor condition that it yielded aunually only 87,750 *kin* of copper. Since the last change of ownership the production has increased year by year and this has become the foremost of the copper mines in Japan.

The rocks are intrusive liparite, with Palæozoic clayslate, sandstone and hornstone. Abundant metalliferous veins traverse the liparite but they thin out in the Palæozoic rocks. There are seven principal veins. The general strike differs, some veins running N.E.–S.W. and others E.–W., all with a high dip. The length is variable, the longest lode being nearly a half *ri*. The breadth is also variable, but generally six or seven feet.

The veinstone consists of quartz and calcite, and generally occurs in small quantities. The ore is chalcopyrite with iron pyrites, and associated with galena, zinc blende and arsenopyrite. The quality of the ore seems to be better in the upper parts of the lodes, where it is altered to bornite and tenorite by weathering. Generally speaking the present prosperity of the mine is due to the regularity and great thickness of the lodes, and the good quality of the ore.

Yield of copper from the Ashio Mine.

	Kin.
1896	9,867,505
1897	8,919,493
1898	9,146,579
1899	9,701,489
1900	10,231,092

Ogoya Mine.—The Ogoya Mine is situated at Nishiomura, Nōmi-gōri, Kaga Province, 5 *ri* southeast of the town of Komatsu.

The mine was discovered by a peasant in 1878. Since then new and rich veins have been found by Yokoyama, the present owner, who has introduced many improvements and thus the mine has gradually increased in productiveness.

Among the numerous veins that are here found in liparite tuff, three are principally worked. They run almost parallel to each other coursing between N.W. and W.N.W., but sometimes cross one another. They dip steeply to S.W. or N.E. at an angle 70°–80°. The breadth varies from one inch to four feet and the length ranges from 500 feet to 2000 feet.

The veinstone is chiefly quartz, often with blocks of the country rock. The ore is chalcopyrite associated with tenorite, bornite, azurite, native copper and iron pyrites.

Yield of copper from the Ogoya Mine.

	Kin.
1896	672,858
1897	706,118
1898	675,298
1899	775,389
1900	172,706

Ate Mine.—The Ate Mine is situated in Ate-mura, Nōmi-gōri, Kaga Province, in a mountainous district, about 2½ *ri* southeast of Komatsu railway station.

The rocks are Tertiary strata and liparite, which contain two principal veins. One of them runs N.–S. with a dip of 70° E. along the boundary between liparite and brecciated tuff, and so it seems to be a contact deposit. Another one runs N. 30° W. with a dip of 70° N.E. and traverses both liparite and breccia. The intersection of the two veins is rich in ore and is 2 or 3 feet thick. Away from this intersection the veins thin out and become inferior in quality.

The ore is chalcopyrite containing iron pyrites, but it is often altered in the upper portion of the veins into bornite and tenorite. The best ore yields over 30% of copper, but the average yield is 10%.

Yield of copper from the Ate Mine.

	Kin.
1898	178,091
1899	219,537
1900	172,706

Omodani Mine.—The Omodani Mine is situated in Kami-Anama-mura, Ōno-gōri, Echizen Province, about 11 *ri* from Ōno and 20 *ri* S.E. of Fukui. It is surrounded by lofty mountains and located about 2500 feet above sea-level, so that communication with it is often cut off in the snowy season.

The mine is said to have been discovered about 550 years ago. About sixty-five years ago it was worked by the lord of the district, Doi by name. After the Restoration of Meiji, Doi transferred the mine to the inhabitants of that village. In 1888 it was transferred to the Mitsubishi Company, the present owner.

The rocks consist of Mesozoic sandstone and quartz-porphyry. Faults running W.N.W. often cut the veins. There are numerous metalliferous veins that generally strike N. 30°–60° W. and dip 50°–80° S.W. None of the veins is more than 4 feet in thickness.

The veinstuff is chiefly quartz mixed with calcite and fluorspar. The ore is argentiferous chalcopyrite with bornite, argentiferous galena, zinc blende, etc. Sometimes native silver is found.

Yield of silver and copper from the Omodani Mine.

	Silver. Momme.	Copper. Kin.
1896	—	207,690
1897	—	385,714
1898	305,918	539,844
1899	297,960	455,741
1900	103,682	469,037

Tsuboi Mine.—The Tsuboi Mine is situated in Tsuboi-mura, Kume-gōri, Mimasaka Province, about 3 *ri* west of Tsuyama, the principal city in the province. It is conveniently situated near the highway leading to Himeji in the province of Harima.

The country rocks consist of an alternation of Palæozoic clayslate and schalstein dipping 60° S. The ore deposit occurs in the form of veins, sometimes running parallel to the plane of stratification. There are found three principal veins which have a thickness of 2–4 feet and are poor in ore content.

The veinstone is quartz. The ore is chalcopyrite associated with iron pyrites, some containing 13% of copper and 0.2% of silver.

Yield of copper from the Tsuboi Mine.

	Kin.
1898	18,890
1899	120,931
1900	140,364

Yamate Mine.—The Yamate Mine is located in Takigawa-mura, Kume-gōri, Mimasaka Province, about a half *ri* south of Yuge and about 8½ *ri* north of the city of Okayama. Yuge is the nearest town to the mine.

There is no authentic record of the discovery of the mine. It was first worked by the feudal lord of Hamada in

1868 and after several changes of proprietors it was reopened and is still worked by Chōbei Nomura.

The mining district consists of quartz-diorite and Palæozoic clayslate, the former being intrusive and the two being intricately mingled. The diorite often shows a schistose structure. The metalliferous veins occur in the periphery of the diorite. Of the two more important veins, one called the Hon-bi is 25 to 30 feet thick, containing silicious clay, while the other one is a very thin deposit.

The ore is chalcopyrite mixed with iron pyrites, galena, and rarely zinc blende. The best ore yields from 10% to 13% of copper and some of it contains a small quantity of silver.

Yield of silver and copper from the Yamate Mine.

	Silver. Momme.	Copper. Kin.
1898	11,360	62,813
1899	3,044	76,091

Kōei Mine.—The Kōei Mine is in Tsunekanemaru-mura, Ashina-gōri, Bingo Province, about 3½ *ri* to the northwest of the town of Fukuyama, where there is a railway station.

It was an abandoned mine, of which there was no record, when it was reopened by Takayama in 1893. Since then it has been continuously worked.

Hornblende-granite is the country rock in this district and its fissures are filled up with ore. The veins generally strike S.W.-N.E. with a dip of 70° S.E.

The veinstone consists of bluish hornblende and talc, in which the masses of ore are frequently enclosed. The thickness of the deposit is from 4 to 8 feet. The ore is chalcopyrite associated with micaceous hematite, iron pyrites and a small quantity of zinc blende. The ore is rather inferior in quality, the dressed ore yielding 13.4% of copper and 4% of silver.

Yield of copper from the Kōei Mine.

	Kin.
1898	125,665
1899	88,797
1900	67,554

Kokusei Mine.—The Kokusei Mine is in Kawabe-mura, Shōnan-gōri, Mimasaka Province, very conveniently located only 1 *ri* east of Tsuyama, the chief town of the province.

The mine was first opened in 1882 and since 1885 has become gradually more productive.

The geological formation is partly Palæozoic, an alternation of sandstone and clayslate, and this is surrounded by Tertiary tuff and penetrated by a propylite dyke. The Palæozoic strata strike N. 20°–60° E. and dip 20°–30° N.W. The ore deposit occurring in rounded or lenticular masses, the largest being nearly 60 feet in diameter, is found between the Tertiary tuff and the Palæozoic strata, in a line running E.–W. It has such a close connection with the propylite dyke that the latter is a guide in following the lode and the deposit is probably a result of contact action. The masses of ore are enclosed by layers of a clayey substance which consists of limestone, serpentine and tuff. The ore is chalcopyrite mixed with iron pyrites, accompanied by a small quantity of zinc blende.

Yield of copper from the Kokusei Mine.

	Kin.
1898	189,401
1899	266,029

Obie Mine.—The Obie Mine is located in Nakanoshō-mura, Tsu-gōri, Bitchū Province, on a hill side about 1 *ri* to the east of Kurashiki railway station.

The mine was opened in ancient times, and was in a primitive state until 1890 when it came into the hands of Sakamoto.

The district consists of Palæozoic clayslate penetrated by granite. There are found numerous metalliferous veins in the clayslate, of which two, the Sarubiki and the Daitō contain the principal workings. The Sarubiki vein runs E.-W. with a high inclination to the south. On the east it is cut by a great fault, and the lode turns to N.N.E dipping to W.N.W. This part with different strike is called the Daitō vein. The breadth of the veins varies from 2 feet to 4 feet.

The veinstone is quartz; the ore is chalcopyrite mixed with iron pyrites and a small quantity of argentiferous galena. The best ore yields 12.62% of copper and 0.008% of silver.

In the neighbourhood of this mine there are several veins worked by private parties on a small scale. The mode of occurrence of the ore is the same as at the Obie Mine.

Yield of copper from the Obie Mine

	Kin.
1896	869,944
1897	986,795
1898	1,034,275
1899	1,005,149

Adakai Mine.—The Adakai Mine is situated in Adakai-mura, Yatsuka-gōri, Izumo Province, about 2½ *ri* southeast of the town of Matsue on the coast of this province.

The country rocks are Tertiary shale and sandstone in alternation. The chief vein, called the Moto-bi, strikes N.N.E. and dips E.S.E. at a high angle.

The veinstuff consists of clay with a thickness of from two to five feet. The ore consists of chalcopyrite, bornite and iron pyrites accompanied by native copper and zinc blende.

Udo Mine.—The Udo Mine is situated in Usagi-mura, Hikawa-gōri, Izumo Province.

It was very extensively worked from 1870 to 1881, in some years producing 60,000 *kin* monthly. After that time the output gradually declined on account of the exhaustion of the supply of good ore.

The country rocks are augite-andesite, propylite, and the Tertiary strata. Numerous metalliferous veins are contained in the propylite, which, near the veins, is greatly altered by iron-oxide. The principal vein, running N.N.W., is 320 feet long and from 3 to 18 feet wide.

The ore is chalcopyrite accompanied by barite, limonite, hematite, bornite etc. Beautiful crystals of iron pyrites are often found.

The production of copper from the Udo Mine in 1900 was only 9,006 *kin*.

Dōgamaru Mine.—The Dōgamaru Mine is located in Ago-mura, Ōchi-gōri, Iwami Province.

The mine was opened about 470 years ago and actively worked for some time, but the working was afterwards stopped. In 1873 the mine was reopened and since 1887 it has gradually become more productive.

The rocks of the mine consist of granitic-porphyry penetrated by coarse grained biotite-granite. Numerous veins are found in the granitic-porphyry, the chief of them being known as the Moto-bi, the Ōzuri-bi and the Kagari-bi, all of which have a great thickness. The copper ore of the Kagari-bi is mixed with iron pyrites and zinc blende; while that of the Ōzuri-bi contains no zinc blende and is poorer in copper.

The principal vein is the Moto-bi with a breadth of from 10 to 25 feet. It strikes S. 50°–60° W. and dips 60°–70° S.E. In the adit-level several dykes of propylite are met with, by which the vein is often dislocated from ten to twenty feet. The veinstone is quartz; the ore is chalcopyrite mixed with argentiferous galena. The upper part of the vein, which contains zinc blende, is poorer in silver and contains less veinstone. It formerly produced native copper and azurite. Going downwards the proportion of veinstone increases and the ore becomes richer in silver.

Yield of silver and copper from the Dōgamaru Mine.

	Silver.	Copper.
	Momme.	Kin.
1896	537,722	578,086
1897	458,060	481,549
1898	307,446	376,333
1899	555,810	510,940
1900	6,056	420,736

Zōmeki Mine.—The Zōmeki Mine is situated in Ikumo-mura, Abu-gōri, Nagato Province.

The rocks of the mine consist of clayslate, sandstone, schalstein and limestone of the Palæozoic System, penetrated by several liparite dykes. The deposits have a close connection with the liparite dykes, and occur in two forms: one a series of pockets, and the other true veins running from E.S.E. to W.N.W.

The veinstuff consists of hornblende, garnet, epidote, calcite and quartz, showing the contact origin of the veins. The ores are chalcopyrite, bornite, zinc blende, galena, and pyrrhotite, containing a small quantity of silver.

Hōgashō Mine.—The Hōgashō Mine is inconveniently situated in a mountainous region in Hatayama-mura, Aki-gōri, Tosa Province. It is about 4 *ri* north of the town of Aki.

The rocks consist of shale and sandstone with intercalated red and green schalstein, probably of the Mesozoic age. The ore is deposited in a lenticular mass within schalstein and is enveloped in a serpentinous substance, locally named *abura-ishi* (oil stone). The deposit strikes east and west, and has a high dip to the north.

The ore is chalcopyrite mixed with iron pyrites, and contains about 7% of copper.

Yield of copper from the Hōgashō Mine.

	Kin.
1898	106,034
1899	162,088
1900	105,368

B. BEDDED DEPOSITS.

Kune Mine.—The Kune Mine is situated in Sakuma-mura, Toyoda-gōri, Tōtōmi Province, a half *ri* from Nishiwatari and 19 *ri* north of Hamamatsu.

There is no authentic record of the discovery of the mine, but it is said to have been opened in 1726. Afterward it was abandoned for a long time. In 1892 the mine was transferred to Ishida and Hara, who discovered a large metalliferous bed in 1898. In the next year it came into the possession of Ichibei Furukawa who is now going to work it on a large scale.

The metalliferous beds are imbedded in graphite- and chlorite-schists of the crystalline-schist system. They dip with the schists 50° W.N.W. The lowest bed has a thickness of 6 feet, but as the dip is followed downwards it splits into two beds each 2 feet thick; the middle bed lies 60 feet above the former and is 12 feet thick; and the upper bed lies from 50 to 60 feet above the middle one and is 100 feet thick. This is the bed that was discovered in 189S and that is the most promising. The beds form lenticular masses. The ore is chalcopyrite mixed with iron pyrites, containing 6% or 7% of copper.

The production of copper in 1898 was 105,104 *kin.*

Tateri Mine.—The Tateri Mine is situated in Nosakogawa-mura, Yoshino-gōri, Yamato Province.

The district consists of Palæozoic clayslate and sandstone in alternation, which gently dip toward N.W. The deposits occur in irregular beds, which sometimes swell to a thickness of 20 to 30 feet, but soon thin out. There are three faults which run almost parallel to each other from E.N.E. to W.S.W.

The ore is a fine admixture of chalcopyrite and iron pyrites. The production of copper in 1899 was only 17,806 *kin*.

Kawadayama Mine.—The Kawadayama Mine is located in Sanyama-mura, Oe-gōri, Awa Province. About 1 *ri* north of the mine, there runs the highway along the Yoshinogawa leading to the city of Tokushima at a distance of about 8 *ri*, and thus the mine is conveniently situated for transportation and communication.

The rocks consist of an alternation of chlorite-amphibolite and graphite-sericite-schist, with thin layers of intercalated piedmontite-schist. The rock formation strikes east and west and has a high dip southward. The ore deposit is mostly imbedded in the chlorite-amphibolite and close to the piedmontite-schist. It varies from 2 to 4 feet in thickness.

The ore is chalcopyrite mixed with iron pyrites, the average proportion of copper being 4%.

Yield of copper from the Kawadayama Mine.

	Kin.
1898	17,852
1899	21,378
1900	11,324

Hisamune Mine.—The Hisamune Mine lies on the boundary between the villages of Kawadayama and Kawada, Oe-gōri, Awa Province, and near the Kawadayama Mine. Being as conveniently situated as the latter, it has undergone quick development.

The rocks are an alternation of chlorite-amphibolite, graphite-sericite-schist and piedmontite-schist. The ore deposit is imbedded in chlorite-amphibolite, dipping highly southward. The bed often contains bands of the country rocks and a black substance resembling magnetite. The bed is sometimes curved and sometimes broken, including fragments of country rocks in the spaces thus formed. The thickness is from 2 to 5 feet.

The ore is chalcopyrite. The average percentage of copper is 4%, and the best ore contains a small quantity of silver.

Yield of copper in 1899 from the Hisamune Mine, 85,646 *kin.*

Higashiyama Mine.—The Higashiyama Mine is located in Higashiyama-mura, Oe-gōri, Awa Province.

The district is formed of an alternation of spotted chlorite-schist and graphite-sericite-schist, with intercalated piedmontite-schist. The ore deposit lies in chlorite-schist and has a high dip to the south. The thickness is generally 2 or 3 feet. The beds are generally found within a limit of 30 feet above the horizon of the piedmontite-schist. The beds occur in lenticular form and often contain gangues (locally known as *naka-ishi*) of varying thickness. Though the strata are not unfrequently disturbed by faulting, they run with the beds generally from east to west.

The ore is chalcopyrite mixed with iron pyrites, and yields from 2% to 2.5% of copper. The production in 1898 was 79,790 *kin.*

Besshi Mine.—The Besshi Mine is located in Besshiyama-mura, Uma-gōri, Iyo Province, on the northern side of the mountain range between Iyo and Tosa, and 3,600 feet above the sea level. It is 3 *ri* south of the town of Niihama on the northern coast of Shikoku. A railway connects the mine with Niihama. The mine is owned by the Sumitomo firm.

The mine was discovered by an ancestor of the Sumitomo family in 1690 and was opened in the next year. At that time there was an old mine called the Tachikawa Mine on the opposite side of the mountain. In 1695 the new mine was worked so far into the mountain as to meet the Tachikawa Mine accidentally, and it was thus known that both mines were in the same bed of ore. The Tachikawa was afterwards amalgamated with the Besshi Mine. The annual production of copper reached 2,500,000 *kin* in 1698.

The rocks consist of graphite-schist and chlorite-schist interstratified with piedmontite-schist and quartz-schist. The ore bed is found in the alternating layers of graphite-schist and chlorite-schist, generally enveloped by a quartz-schist known as *habu*. They dip 45° N.E. At present the worked length of the beds is 6,000 feet. The thickness of the bed varies from 4 to 30 feet, but is commonly from 10 to 20 feet. Step-faults running almost parallel from east to west are frequently met with. The amount of the throw in the step-faults is generally from 10 to 20 feet and never exceeds 60 feet.

The ore is chalcopyrite containing a large amount of iron pyrites and small quantities of arsenic, cobalt, manganese and lead. The ore contains 6% of copper.

Yield of copper from the Besshi Mine.

	Kin.
1896	4,625,711
1897	4,875,265
1898	4,919,298
1899	6,210,961
1900	6,107,061

Nishinokawa Mine.—This is a subordinate mine under the same control as the Besshi Mine, and is in Ōboki-mura, Nii-gōri, Iyo Province, about 7 *ri* south of the town of Saijo. It is on the northeastern foot of Ishizuchi-yama which consists of propylite. Being situated in a high mountainous region, this mine is somewhat difficult of access.

The ore deposits occur in the lenticular form in chlorite-schist, dipping 35°–70° S.W. They are from 3 to 12 feet thick. The deposits are not accompanied by the quartzose rock (the so-called *habu*) which is always found in the Besshi Mine. Near the volcanic rock of Ishizuchi-yama, the strata of the crystalline-schist are more or less dislocated and a part of the ore deposits is brecciated and altered into cuprite.

The ore is chalcopyrite mixed with iron pyrites, hematite, zinc blende, magnetite and quartz. It contains from 3% to 4% of copper.

Yield of copper from the Nishinokawa Mine.

	Kin.
1898	184,386
1899	166,294
1900	140,012

Kurotaki Mine.—The Kurotaki Mine is in Motokawa-mura, Tosa-gōri, Tosa Province. It is situated about 2 *ri* south-east of the Besshi Mine over a high ridge on the boundary between Iyo and Tosa.

The ore deposits occur in chlorite-schist, dipping to the S.S.W. with an angle of 30°. The beds are contorted, the saddles and the troughs being specially thick and workable. Their greatest thickness is generally 10 feet.

The ore is chalcopyrite which, according to its quality, is divided into two kinds, superior and inferior. The superior contains 10% of copper and the inferior contains from 2% to 4%.

Yield of copper from the Kurotaki Mine.

	Kin.
1898	67,524
1899	100,827
1900	115,939

Hokoishi Mine.—The Hokoishi Mine is situated in Kamo-mura, Nii-gōri, Iyo Province. It was discovered in 1890.

The ore deposit is found in chlorite-amphibolite, striking approximately from east to west. It is folded with the country rocks and is often split into several branches. The average thickness of the deposit is about 1 foot.

The ore is chalcopyrite containing iron pyrites and yields only from 3.5% to 4% of copper.

The production of copper in 1900 from the mine was 39,980 *kin.*

Terano Mine.—The Terano Mine is situated in Saretani-mura, Iyo-gōri, Iyo Province.

The country rocks consist chiefly of chlorite-schist. The ore bed runs from east to west and dips gently to the north. It is sometimes 7 feet thick, but commonly from 1 to 2 feet.

The ore is chalcopyrite mixed with iron pyrites and yields 4% or 5% of copper.

The yield of copper from the mine in 1898 was 19,828 *kin.*

Ose Mine.—The Ōse Mine is situated in Ōse-mura, Kita-gōri, Iyo Province.

The country rock is an alternation of chlorite-schist and graphite-sericite-schist, striking N.W.–S.E. and gently dipping to N.E.

The ore deposits occur in irregular forms of varying size, generally lenticular. The largest deposit is 230 feet long, 100 feet wide, and 43 feet thick.

The ore is chalcopyrite associated with iron pyrites, and yields 3% or 4% of copper.

The production of copper from the mine in 1900 was only 7,196 *kin*.

Hibira Mine.—The Hibira Mine is located in Kitakata-mura, Higashi-Usuki-gōri, Hyūga Province, on the eastern bank of the Tsunanose-gawa, a branch of the Gokase-gawa running from west to east across the middle part of Hyūga. The Gokase-gawa makes transportation convenient.

There is no record as to the early history of the mine, except that it was in prosperous state at the end of 17th century.

The country rocks consist of phyllitic clayslate, sandstone and schalstein of the Palæozoic Group. The high mountains to the north of the mine are formed of quartz-porphyry, which has intruded through the Palæozoic strata. The ore beds lie in clayslate and sandstone, and generally close to schalstein. They strike W.N.W. and dip N.N.E., at an angle of 10°. The beds occur in the form of lenses, sometimes with a thickness of about 20 feet.

The ore is chalcopyrite containing iron pyrites, and yields 5% or 6% of copper.

Yield of copper from the Hibira Mine.

	Kin.
1896	861,853
1897	1,005,688
1898	1,281,367
1899	1,367,293
1900	1,350,762

Makimine Mine.—The Makimine Mine is located opposite to the Hibira Mine across the Tsunanose-gawa.

It was a dead mine until it was reopened by the Mitsubishi Company.

Its geology is nearly the same as that of the Hibira Mine, with only difference of strike (E.N.E.) and dip (30° N.N.W.). The ore contains a large quantity of iron pyrites, consequently yielding only 3.5% or 4% of copper.

Yield of copper from the Makimine Mine.

	Kin.
1896	726,673
1897	888,391
1898	896,649
1899	959,068
1900	922,353

Sawatari Mine.—The Sawatari Mine is situated at Kitakata-mura, Higashi-Usuki-gōri, Hyūga Province, about 1 *ri* south of the Hibira Mine.

This mine was opened about 200 years ago and was fairly productive from the first. At present it belongs to the Mitsubishi Company.

The deposits occur in the lenticular form in the Palæozoic clayslate and sandstone, dipping 30° N. Their thickness varies from 1 to 3.5 feet. The ore is of the same kind as that of the Makimine Mine.

Yield of copper from the Sawatari Mine.

	Kin.
1896	256,727
1897	323,058
1898	406,109
1899	217,066
1900	104,726

Itsuki Mine.—The Itsuki Mine is situated in Itsuki-mura, Kuma-gōri, Higo Province, 6 *ri* north of Hitoyoshi which is the chief town in the southern part of Higo.

The mining district is formed of the Upper Chichibu series of the Palæozoic age, and consists of radiolarian slate, schalstein, clayslate and greywacke. The rocks strike N. 50°–60° E. and dip 50° N.W. The ore deposit is interbedded in clayslate and has the same strike and dip with the country rocks. The average thickness is 4.5 feet.

The ore is chalcopyrite containing iron pyrites and yields 5% or 6% of copper.

Yield of copper from the Itsuki Mine.

	Kin.
1898	791,906
1899	841,929
1900	824,552

Fukada Mine.—The Fukada Mine is situated in Fukada-mura, Kuma-gōri, Higo Province, about 3 *ri* to the east of the town of Hitoyoshi.

The country rock is an alternation of sandstone and clayslate of the Palæozoic Group. In the western part of the mining district, the general strike of the strata is N.–S. and the dip is 40°–60° W.; but in the east the strike changes to N.W. and the dip to S.W. The ore deposit has the same strike and dip with the country rocks. Its thickness is sometimes over 10 feet, but commonly 5 feet.

The ore is the same as that of the Itsuki Mine.

Yield of copper from the Fukada Mine.

	Kin.
1898	10,132
1899	18,093
1900	13,944

XI. IRON MINES.

Kamaishi Mine.—The Kamaishi Mine is situated in Kami-Hei-gōri, Rikuchū Province. The deposits are scattered on the eastern and western sides of Kataba-san around which lie the three villages of Kashi, Kamigō and Kurihashi, and which is about 4000 feet high above the sea level. The district is about 5 *ri* west of Kamaishi harbour, with which the mine is connected by a tramway.

The mine was discovered about 1823 and metallurgical operations were commenced 25 years later. After it had been transferred several times from one proprietor to another, the government bought it in 1874 and introduced various improvements under the direction of six English engineers. But owning to the poor results, the government was obliged to stop the work. Afterward Ichibei Tanaka bought the mine and introduced many improvements, so that it became the principal iron mine in Japan.

The rocks are granite and diorite penetrating the Palæozoic limestone, clayslate and hornstone. The ore deposits which consist of magnetite, occur in large scattered masses in the contact zone of the Palæozoic rocks with the granite, and are enveloped by various contact minerals such as garnet, pyroxene, epidote etc. The deposits extend from Takinosawa to Aonoki, through Shintaneyama, Motoyama, Sahinai and Akaiwa. The principal deposit has a thickness of from 20 to 70 feet. Some of the ores of Shintaneyama and Motoyama contain iron pyrites but in small quantities. Besides these, there are many outcrops in other localities, as Hosogoe, Sotohisagosawa, and Ōtakisawa. The deposits at Hosogoe and Sotohisagosawa are inferior in quality and not so thick, while that at Ōtakisawa has a thickness of about 20 feet and is generally of good quality.

The ore is everywhere magnetite.

Yield of pig-iron from the Kamaishi Mine.

	Kwan.
1896	4,111,353
1897	4,303,030
1898	3,620,927
1899	3,429,117
1900	3,648,673

Sennin Mine.—The Sennin Mine is situated at the foot of Sennin-yama in Waga-gōri, Rikuchū Province, about 10 *ri* west of Kurosawajiri railway station.

The rocks are gneissic granite and limestone, which are covered by Tertiary strata. The deposit is found in the contact zone of limestone with gneissic granite, ranging from Tohira to Semmai, Ubasugihitō, Kanahata and Yatatezawa. It strikes from N.N.W. to S.S.E. and dips steeply to E.N.E. Contact minerals such as hornblende, garnet etc., are often associated with the deposit. The thickest part of the deposit is as much as 24 feet through, but more commonly it is about 10 feet. The ore is hematite sometimes with iron pyrites.

Yield of iron ore in 1900 was 28,397 *kwan.*

Kuriki and Omakigura Mines.—The Kuriki and Omakigura Mines are situated in Yonesato-mura, Ezashi-gōri, Rikuchū Province, about 6 *ri* distant from the town of Iwayadō.

The iron deposits lie in the contact zone of Palæozoic rocks with granite, outcropping at Danohana, Tsutsujigamori, Akagane etc. The breadth of the deposits is generally 50 feet.

The ore is magnetite but is often accompanied by a small quantity of chalcopyrite and iron pyrites, as in Akagane and Danohana.

Akadani Mine.—The Akadani Mine is situated in Akadani-mura, Kita-Kambara-gōri, Echigo Province.

The deposits are imbedded in the contact zone of Palæozoic limestone with granite and have a breadth of from 5 to 15 feet. The ore is chiefly micaceous hematite with more or less chalcopyrite and iron pyrites.

Nakakosaka Mine.—The Nakakosaka Mine is situated in Kosaka-mura, Kanra-gōri, Kōtsuke Province.

The deposit is imbedded near the contact zone of Palæozoic clayslate, sandstone and hornstone with schistose granite. It strikes N. 30 W. and dips to N.E. The ore is chiefly magnetite, rarely associated with iron pyrites.

XII. IRON SAND.

Iron sand in Japan is chiefly found in the mountainous region of Chūgoku, mostly coming from the disintegration of granite, diorite and basic volcanic rocks. Those sands contained in diorite and volcanic rocks are mixed with titaniferous iron and bisilicates, so that the quality is inferior to those from granite. The original sand generally contains one to six per cent. of iron.

The principal localities of iron sand are as follows:

Ebi, Hino-gōri, Hōki.
Fukuoka, „ „
Inga, „ „
Hatanaka, „ „
Vicinities of Tari, Hino-gōri Hōki.
Shinjō, Maniwa-gōri, Mimasaka.
Izuha, Ōchi-gōri, Iwami.
Yakami-gawa, „ „
Takano, Yamagata-gōri, Aki.
Ōtsuka, „ „
Environs of Kuriya, Takada-gōri, Aki.

Kishima, Iishi-gōri, Izumo.
Kamiai, Nita-gōri, „
Nishi- and Higashi-Hitagawa, Nōgi-gōri, Izumo.
Aburaki, Hiwa-gōri, Bingo.
Misaka, „ „
Vicinities of Miyauchi, Hiwa-gōri Bingo.
Okamibuchi, Futami-gōri, Bingo.
Hitsuda, „ „
Moda, „ „

XIII. TIN MINES.

Kiura Mine.—The Kiura Mine is situated in Kiura-mura, Ōno-gōri, Bungo Province, near the boundary between Bungo and Hyūga and almost completely surrounded by lofty mountains.

The mine was discovered many hundreds of years ago and was once prosperous. But at present the work is stopped as the ore is almost exhausted.

The mining district consists of the Palæozoic rocks with a thick bed of limestone, which are penetrated by granite and quartz-porphyry. In the limestone are numerous cavities caused by the solvent action of water, and all the cavities are filled up with reddish brown clay which always contains more or less tin ore (cassiterite). Thus the ore is evidently so-called stream tin carried by running water and deposited in the limestone cavities. The dimensions of the cavities are variable, some of them measuring over 10 cubic feet in capacity. The tin ore is occasionally found disseminated in a vein. Associating minerals are quartz, limonite, iron pyrites, chalcopyrite, cerussite, pyromorphite, malachite, arsenopyrite, ilmenite, etc.

Taniyama Mine.—This famous tin mine is situated in

Taniyama-mura, Kagoshima-gōri, Satsuma Province, 5 *ri* south of the city of Kagoshima.

It was discovered in 1655 and was most productive between 1848 and 1860, annually yielding from 120,000 to 130,000 *kin* of tin.

The rocks consist of clayslate and sandstone probably of Mesozoic age, often penetrated by augite-andesite dykes. The deposits are found in the form of veins. These veins are numerous but only three of them are much worked. They run almost parallel from east to west and dip to the south at an angle of 60°. The thickness of the largest vein is over 3 feet, but the others are much smaller.

The ore is fine-grained cassiterite associated with quartz, galena, iron pyrites, zinc blende and rarely wolframite. It contains 3% of tin. The production of tin from the mine in 1899 was 26,228 *kin*.

XIV. STREAM TIN.

Stream tin is found in the vicinity of Takayama and Hirukawa, over an area of about 2 *ri* square, on the banks of the Kiso-gawa, in Ena-gōri, Mino Province, not far from the town of Nakatsugawa.

Granite constitutes the mountains of this region and is considered to be the mother rock of the tin ore. Cassiterite occurs as grains in the gravel layer on the banks of the river, associated with iron sand, topaz, beryl, sapphire, wolframite and fergusonite.

XV. ANTIMONY MINES.

Kano Mine.—The Kano Mine is situated in Kano-mura, Tsuno-gōri, Suō Province.

The country rocks are Mesozoic sandstone, clayslate and conglomerate. There are four principal veins running east and west, and dipping highly northwards. The ore is stibnite.

Yield of regulus and sulphide of antimony from the Kano Mine.

	Regulus. Kin.	Sulphide. Kin.
1899	189,032	321,695
1900	237,786	7,560

Ichinokawa Mine.—The Ichinokawa Mine is situated in Ōjoin-mura, Nii-gōri, Iyo Province, at a distance of 1½ *ri* from the town of Saijō, whence the metal is shipped.

The mine was discovered about 200 years ago, but it was not until 1885 that it attained much importance. At present it is the most productive antimony mine in the world.

The rocks of this district are graphite-schist of the Crystalline-schist System and Cretaceous conglomerate consisting of fragments of crystalline-schists. The deposits are found in the form of veins traversing these rocks from east to west. In this mine there are two classes of lodes, known as Yoko-hi and Tate-hi.

The Yoko-hi (horizontal vein) inclines gently southwards. It has a wide extension in the conglomerate and attains a thickness of about 6 feet. It is this vein that yielded a large amount of ore and that made the mine famous for a time as the sole producer of antimony in Japan. Large and splendid crystals of stibnite were formerly found in this vein, but these seem now to have been almost exhausted.

The Tate-hi (vertical veins) stand nearly vertical, and run parallel to each other from E.N.E. to W.S.W. Of these, the Senga-bi, Kame-bi and Tsuru-bi are the principal veins. The Senga-bi occurs in the crystalline schist extending eastward so far as to meet with the southern part of the Yoko-hi. The Kame-bi and the Tsuru-bi are to the south of the Senga-bi; on the east they run separately, but on the west they unite, the junction being more than 6 feet thick, and being as productive as the Yoko-bi.

Beside the above mentioned veins there are many other smaller workable ones in the mining district.

The ore is stibnite mixed with more or less quartz, sometimes with calcite and feather-ore.

Yield of regulus and sulphide of antimony from the Ichinokawa Mine.

	Regulus. Kin.	Sulphide. Kin.
1898	89,799	1,159,405
1899	185,141	786,693
1900	342,682	100,297

XVI. MANGANESE MINES.

Ribets Mine.—The Ribets Mine is situated in Ribetsmura, Setana-gōri, Shiribeshi Province, Hokkaidō.

Black earthy manganese ore is found in Tertiary tuff in the form of veins:

Yield of manganese ore from the Ribets Mine.

	Kin.
1898	672,000
1899	375,000
1900	3,066,708

Fukaura Mine.—The Fukaura Mine is situated in Fukaura-mura, Nishi-Tsugaru-gōri, Mutsu Province.

The manganese ore deposits are found in the contact zone of Tertiary tufaceous sandstone with andesite, or in fissures of the andesite. The widest part of the vein is 20 feet.

Yield of manganese ore from the Fukaura Mine.

	Kin.
1898	2,312,422
1899	2,295,216
1900	3,310,600

CHAPTER X.

NON-METALLIC MINERAL PRODUCTS.

I. GRAPHITE.

Graphite occurs in crystalline schists and in other stratified rocks in contact with eruptive rocks. It is found in two forms, scaly and massive; the scaly form is found in Hida and Suō, and the massive form is found in Kaga, Satsuma and other provinces.

The principal localities are as follows:

Hosoiri, Nei-gōri, Etchū.
Nishidani, Enuma-gōri, Kaga.
Kawai, Yoshiki-gōri, Hida.
Wagō and Hiake, Higashi-Kamo-gōri, Mikawa.
Tabara, Minami-Shidara-gōri, Mikawa.
Kuga-gōri, Suō.
Asa-gōri, and Toyora-gōri, Nagato.
Kaseda, Kawanabe-gōri, Satsuma.

II. COAL.

The oldest coal in Japan is found in the Mesozoic formation. The anthracites of Mine-gōri in Nagato and Kawakami-gōri in Bitchū, occur in the upper Triassic and the Jurassic Systems; those of Tanimura in Echizen, Shitaka in Tango, and Tsukiki in Tamba in the Jurassic System; and those of Amakusa in Higo and Miyai in Kii are in the Cretaceous System. In the Cretaceous System of Ryōseki in Tosa and of the Katsuragawa basin in Awa are intercalated a few coal seams of an inferior quality. Coal seams of far greater importance are found in the Tertiary System. Of the Tertiary coal-fields those of Kyūshū and Hokkaidō are the most extensive and valuable. In Honshū there are no remarkable coal-fields except one extending over Iwaki and Hitachi which yields coal inferior to that of Kyūshū and Hokkaidō in quality as well as in quantity. The principal coal-fields in Kyūshū are those of Miike and of Chikuhō i.e. Chikuzen and Buzen, and the coal-fields of the province of Ishikari are the most important in Hokkaidō. The total production of coal in Japan during 1899 amounted to 6,721,798 tons, 70% of which was the output of the coal-fields of the three districts just named.

The quantity of coal raised in Japan from 1890 to 1899 is as follows:

	Output in tons.	Ratio to output of 1890 taken as 1000.
1890	2,608,284	1000
1891	3,175,844	1218
1892	3,175,670	1217
1893	3,319,601	1272
1894	4,268,135	1636
1895	4,772,654	1830
1896	5,019,690	1925
1897	5,188,157	1989
1898	6,696,033	2567
1899	6,721,798	2577

Collieries which produced over 80,000 tons during 1899 are as follows:—

Hokkaidō. Total production 633,282 tons.

	Tons.
Yūbari	259,794
Poronai	121,788
Kami-Otaushinai	113,975

Fukuoka Prefecture. Total production 4,468,905 tons.

	Tons.
Miike	712,564
Namazuta	206,711
Shinnyū	191,714
Akaike	168,212
Nara	163,630
Daijō	151,019
Kaneda	108,160
Kawamiya	100,888
Dainoura No. 1	98,069
Toyokuni	96,939
Dainoura No. 2	89,733
Hontō	85,511
Usui	83,869
Takao	82,586

Nagasaki Prefecture. Total production 414,858 tons.

	Tons.
Takashima (including Hashima)	165,232

Saga Prefecture. Total productions 520,849 tons.

	Tons.
Yoshinotani	87,384

The following table shows the analyses of the coals from the principal coal-fields of Japan.

Localities.	Names of Coals.	Water.	Volatile Matter.	Coke.	Ash.	Sulphur.	Caking Qualities.	Sp. Gravity.	Calorific power.
Chikuhō Coal-field.	Shinnyū 3 ft. Seam.	3.41	42.76	48.46	5.37	0.22	Cakes pretty compactly.	1.311	—
"	Akaike 5 ft. Seam.	2.64	43.99	50.44	2.93	0.41	Cakes and swells.	1.275	75.90
"	Namazuta Chirimen Coal.	1.66	42.50	52.68	3.16	0.81	"	1.298	75.90
"	Miike 8 ft. Seam.	0.70	42.15	48.85	3.30	3.34	"	1.278	—
Hizen Coal-field.	Takashima Coal.	0.98	39.08	53.42	6.53	0.65	"	1.270	80.30
Ishikari Coal-field.	Yūbari Coal.	1.46	42.89	57.11	4.57	0.31	Cakes.	1 200	—
"	Poronai Coal.	5.09	42.19	48.80	3.92	0.25	Cakes compactly.	1.306	—
Hitachi-Iwaki Coal-field.	Shiramizu Coal.	5.06	44.36	40.81	8.75	1.39	Does not Cake.	1.304	—

The chief coal-fields of Japan are described below. Besides these, small coal-fields yielding coals of inferior qualities are found in the provinces of Echigo, Shinano, Ugo, Rikuchū, Mutsu, Kai, Yamato, Bitchū, etc.

A. ANTHRACITIC COAL.

Coal-field of Moriyoshi, Ugo.—This coal-field occupies a small area, in the mountains between Maeda and Nanukaichi in Kita-Akita-gōri, with outcrops in Yunoshirisawa, Akarimata, and Osawa-mura. An anthracite seam of 7 feet is found in the Tertiary strata, which are disrupted by volcanic rocks in different places. The seam usually contains many thin bands of shale. Portions of the seam in contact with andesite dykes have been changed into natural coke.

Coal-field of Higashi-Muro-gōri, Kii.—Anthracite seams from 1 to 4 feet thick are found in Mesozoic shale on the west banks of the Kitayama-gawa and the Totsu-gawa. The seams have the prevailing dip of 10°–15° S.S.E. Collieries are located at Miyai, Otogawa, Okudani, Matsuzawa, etc.

Results of analyses and output of anthracite are as follows:—

	Water.	Volatile Matter.	Coke.	Ash.	Sulphur.
Miyai Colliery	2.40	5.48	90.09	2.03	—
Matsuzawa Colliery ...	8.88		84.11	5.16	1.85

PRODUCTION IN 1899.

	Tons.
Miyai Colliery...	11,562
Otogawa and Okudani Collieries...	7,456
Matsuzawa Colliery	13,434

Mesozoic Coal-field of Nagato.—Impure anthracite seams are intercalated in the Triassic and Jurassic Systems in Mine-gōri, Toyora-gōri, and Asa-gōri. They occur in lenticular forms not exceeding generally 3 feet in thickness, and they dip at high angles. The anthracite is got mostly broken into fine pieces. Outcrops are found in Tsubuda and Kajiura in Asa-gōri, and Ofuku, Ōmine, Isa, Atsu etc., in Mine-gōri.

Amakusa Coal-fields.—The Cretaceous anthracite field of Shimojima, one of the Amakusa Islands, province of Higo, may be divided into two, the northern and the southern. The northern field stretches along the coast for about 2 *ri* from Kamitsu-fukae to Tororo. There are three coal seams, of which the upper one is 0.8 of a foot thick, the middle one 2 feet and the lower from 1.5 to 4 feet; they dip 30°–50° N.W. or W. The southern field stretches for about 3½ *ri* from Itchōda to Ushibuka. The seams are more or while the latter is caking and smoky. Of Sorachi coals, which are in general less lustrous, those from the northern part of the field are weakly caking while those from the southern are strongly caking.

The principal mining districts in the extensive Ishikari coal-field are as follows, beginning from the north:

Sorachi (*Kami- and Shimo-Otaushinai* Collieries):—The thickness of the coal-bearing series is approximatly 4,000 feet. It consists of an alternation of shale and sandstone, in which are intercalated from 8 to 13 coal seams thicker than 3 ft., the average total thickness exceeding 40 ft. Inclination is steep, and faults are numerous.

Ikushumbets:—The workable seams are four in number with an average total thickness of 14 ft. They dip steeply toward the west,—more than forty degrees. Irregular faults are numerous.

Poronai:—There are four workable seams as at Ikushumbets. They form a large anticline with gentle dip. Faults are numerous.

Yūbari:—The Yūbari colliery is located in the southernmost part of the coal-field and is one of the best collieries in Japan. There are two seams 15 feet and 4 feet thick respectively.

The production from 1896 to 1899 from the chief collieries of the Ishikari coal-field was as follows:

	Yūbari.	Kami- and Shimo-Otaushinai.	Poronai.	Ikushumbets.
	Tons.	Tons.	Tons.	Tons.
1896	199,015	84,218	109,905	30,572
1897	281,767	123,415	112,056	40,607
1898	203,422	149,377	139,181	45,745
1899	259,794	127,718	121,788	38,036

Kushiro Coal-fields.—On the coast, east and west of the town of Kushiro, numerous outcrops of coal are found scattered over the length of a hundred kilometers, from Akkeshi to Shakumbets. The average thickness of the seams, which are two or three in number, is about 3 feet; the dip of the seams is gentle. The coal is not good, containing much ash. The mining localities are Shitakaro (5 ft. seam), Kobumori (3 ft. seam), Beppo (two 3 ft. seams), Shakumbets (two 3 ft. seams), Harutori (three 3 ft. seams), Shiranuka, Senrōji, etc.

The production in 1899 from the Kushiro collieries was as follows:—

	Tons.
Beppo	14,919
Harutori...	13,228

Kayanuma Coal-field.—This field lies in Iwanai-gōri, Shiribeshi Province.

There are three six-foot seams, forming an anticline dipping 50° to N.W. and 30° to S.E. The coal contains much ash and sulphur. The Kayanuma colliery is the oldest in Hokkaidō, having been worked since 1868.

Besides the above mentioned localities, outcrops of coal have been found in several places in Hokkaidō. Many of these lie untouched in consequence of the lack of convenient transportation. Workable coal seams are known to occur in the basin of the Makumbets, a tributary of the Someshiri in the province of Hidaka; on the Iraibets, the Onishibets, the Salkots, etc. in the province of Kitami. Coal seams on tributaries of the Mukawa in Iburi have been recently worked.

HONSHŪ.

Aburato Coal-field.—Outcrops of coal of inferior quality are found in a narrow belt close to the coast of

Nishi-Tagawa-gōri, Uzen Province. The Aburato is the principal colliery. Besides, there are minor collieries at Hayama, Higashi-Myōgadai, Matsuozawa etc. The workable seam, which is intercalated in Tertiary shale, has a thickness of from 3 to 5 feet, and dips 20°–60° W. The production in 1899 was 7,332 tons.

Iwaki–Hitachi Coal-field.—This is the largest coal-field in Honshū and extends as far as 21 *ri* along the eastern coast of the provinces of Iwaki and Hitachi. It begins in the south at Tomobe in Hitachi and stretching northward along the eastern side of the Abukuma Mountains reaches to Nogami in Iwaki. The seams are thickest in the region east of Yuno-take and Akai-dake, whence they become gradually thinner northward and southward. The coal-bearing Tertiary strata consist of an alternation of tufaceous shale and sandstone belonging to the Miocene period. The general strike is from north to south, and the inclination is gently eastward. The seams are of brown coal, very inferior in quality, compared with the coals of Kyūshū and Hokkaidō. The chief collieries are those of Onoda, Shiramizu, Iwaki, Iriyama, etc. The total coal raised in 1899 was 317,493 tons.

We shall here give a short description of each coal district, beginning at the south.

In the vicinity of Tomobe in Hitachi, carbonaceous shale about 6 feet thick intercalates thin layers of brown coal. This shale continues northward to the Azuhata Colliery through Ōtsuka, where it attains a thickness of 7 feet and contains five or six coal seams from 5 to 9 inches in thickness. In the Azuhata district, which is a depression region, there are three coal seams dipping 10° eastward. The upper and lower of the three seams are earthy coal with a thickness of from 1.5 to 2 feet. The middle seam is 3 feet thick and contains abundant clay layers. These coals are rich in volatile matter, and contain approximatly 40% of coke, showing a heat power of 5,000 calories. Further north the coal seams exposed in Kamikotsuta, Koyamada, etc. in a district separated by a fault from Azuhata, are inferior in quality. The coal-bearing strata extend to the mining region of Yunagaya, where two workable seams are found; the upper is 4 feet thick and 120 feet below it there is another seam 6 to 8 feet in thickness. The general strike is N.–S. and the dip 12° E.

On the north of Yunagaya are the collieries of Iwaki, Shiramizu, Iriyama, etc. In Shiramizu there are exposed two coal seams in tufaceous sandstone and shale, dipping 20° eastward. The upper seam is 3 feet thick and is not of a good quality. The lower one is 6.4 feet thick, and contains 40% of coke and shows a heating power of 7,000 calories. The coal seam of Shiramizu continues northward to the Miya, Iriyama, and Iwaki collieries, where only the lower seam, 6 or 7 feet thick, and dipping 20° E., is exposed.

This coal has been traced northward through Sakakikoya, Yoshima and Akai. In the Nishi-Ogawa region which lies still further north, seams of coal much cut up by streaks of shale crop out at Aikawa (2 ft.), Yamada (2.6 ft.), Nishi-Ogawa (6 ft.), etc. Further north to Nogami, the end of the outcrop, the coal is worse and the seams thinner.

Tertiary Coal-field of Asa-gōri, Nagato.—This coal-field underlies the villages of Ube, Funaki, Takachiho, Suye, Atsunami, etc. in the southern part of the province of Nagato. Two workable seams, 3 feet and 2 feet thick respectively, are intercalated in gently undulating strata of shale and sandstone. The production of coal from the coal-field during 1899 was nearly 237,000 tons, and the collieries which raised over 10,000 tons in 1899 are as follows:—

Collieries.	Tons.
Ariho	12,714
Okiube	13,551
Ubegata	11,177
Okiyama	11,396
Misome	13,321

KYŪSHŪ.

Chikuhō Coal-field.—The coal-field lying in the two adjacent provinces of Chikuzen and Buzen in Kyūshū, and hence called the Chikuhō coal-field, comprises a wide area extending over Onga-gōri, Kurate-gōri, Munakata-gōri, Kaho-gōri, Kasuya-gōri in Chikugo, and Tagawa-gōri and Hiki-gōri in Buzen. The quantity of available coal in the field is estimated at 87,000,000 tons. The production in 1899 was 3,756,000 tons which is more than one-half of the total production of Japan in the same year.

The coal-bearing Tertiary strata were deposited in basins that had been formed in the older rocks, cutting them about N.N.W.-S.S.E., and the coal-field is accordingly divided by intervening mountains into several troughs running in that general direction. The coal-bearing strata usually form synclinals which dip east gently and west steeply. The coal seams number more than ten, of which the most generally workable are two seams of 3 feet and 5 feet. The coals are of a good bituminous quality and mostly make good coke. There occurs frequently a variety of coal locally known as *senseki*. It has the appearance of an anthracite or a coke, and it decrepitates in fire; it is a natural coke formed in places where the seams come in contact with andesite sheets.

The essential portion of the Chikuhō coal-field occupies the greater portion of the drainage area of the Onga-gawa and its tributaries, extending over Kurate-gōri, Onga-gōri, Kaho-gōri and Tagawa-gōri. The large coal-field which may be rightly called the Onga-gawa Coal-field is divisible naturally into four parts, which division is convenient for descriptive purposes; namely, (*a*) the Onga–Tagawa region occupying the long area on both sides of the main course of the Onga-gawa and its chief tributary the Akaike-gawa and stretching in a N.N.W.–S.S.E. direction over the middle portion of Onga-gōri, the eastern part of Kurate-gōri and the main portion of Tagawa-gōri; (*b*) the Kurate–Kaho region, a narrower belt lying to the west of the first and parallel to it, extending from the western part of Onga-gōri through Kurate-gōri to a point south of Taira in Kaho-gōri; (*c*) the Middle Kaho region, extending from Shōji in Kaho-gōri on the north to Usui in the same district on the south, passing to the west of Iizuka; (*d*) the West Kaho region occupying a small area in the vicinity of Daibu.

a. **Onga–Tagawa Region.**—The synclinal axis passes through the field near the eastern margin. Coal is restricted to the western wing of the synclinal, which dips 10°–20°. Workable seams are more than ten in number. The field is divided into two by the Onga-gawa. The field to the east of the Onga-gawa has seven workable seams from 2 to 5 feet thick, the average total thickness being approximately 24 feet. The coal is of an inferior quality, but it contains none of the carbo-silicified wood, that occurs elsewhere and is locally known as *matsu-iwa.* The outcrops extend from Yamaga on the north to Kakino on the south, the line passing through the Koromatsu, Higashiya, Ōtsuji and Kagawa collieries. In the more important field west of the river outcrops are found at Beppu in Onga-gōri, and continue southward to Tagawa-gōri through Shinnyū, Nōkata, Shimo-sakai, etc. in Kurate-gōri; and the field is 11½ *ri* long from north to south, the widest part reaching to 2 *ri.* There are more than ten seams of which the three-foot and four-foot seams, that are respectively called the "3-foot" and "5-foot" seams, are workable Besides the above, the "Kakuseki" (1.2 ft.), the "Mitani" (1.8 ft.), the "Kankan" (3.5 ft.), the "Yoshinotani" (1.2 ft.), etc. are the names of the chief seams found in the vicinity of Seta. The coals from these workings contain 3% to 15% ash and 41% to 52% coke. Southward at Akaike in Tagawa-gōri the seams are the "3-foot" (2.5 ft.), "5-foot" (4.5 ft.), and Banshita (2.4 ft.). Going still south, at Itoda the "3-foot" seam becomes the "Nanaheta" (5 ft.), and the "5-foot" seam the "8-foot" (6 ft.), and besides there occur 3-foot and 4-foot seams. On the south of Hoshi the coal seams are depressed by a fault. Further southward there are found three seams running nearly parallel to each other through Kawamiya, Nara, Ida, and the former Navy Reserve coal-field. The western one of them is worked at Kawamiya and Nara, showing a succession of strata similar to that in the Itoda colliery. After sinking under the alluvium the coal reappears south of Tabara but there the quality of the seams becomes greatly inferior. The middle zone outcrops in Komatsugaura the outcrop continuing to the Ida colliery, where the "8-foot" seam is changed to a natural coke by the intrusion of andesite dykes, but the lowest "4-foot" seam retains a good quality and extends to the vicinity of Soyeda. The "8-foot" seam of the eastern zone runs southward from Ida; its workable portion is actually about 4 or 5 feet thick.

b. **Kurate-Kaho Region.**—This is a large coal-field next to the above, embracing the coal districts of Nishikawa, Ōkuma, Tsuruda, Katsuno, Shakanō, Namazuta, Tsunabu, etc. A synclinal axis passes through the eastern part of the field, and coal seams are chiefly found in the west wing of the syncline; but north of Miyata outcrops are found in its east wing. The inclination is 15°–20°, and faults are numerous.

The chief seams are the "Kankan" (3 ft.), the "4-foot" (4 ft.) and the "5-foot" (4 ft.), and they contain frequently carbo-silicified wood. The seams disappear at Nagaitsuru owing to a great fault running east and west, but appear again at Ōkuma. That part of the field south of the fault-line contains coal seams of good quality, which have been however intruded upon by volcanic rocks and changed to a natural coke. The "3-foot" and "5-foot" seams are the chief ones, and they have a tendency to become thin and of an inferior quality.

c. **Middle Kaho Coal-field.**—There occur in this field several seams dipping to the east. Faults are numerous. In the east wing of the syncline the coal is restricted to the northern part of the field. The eastern-most zone of the coal extends from Yamano to Kanagahatake, containing the Yamano, Iwasaki, Kami-Yamada, Shimo-Yamada, Ushikuma, and other collieries. The workable seams are the "8-foot" (3.5 ft.) and the "5-foot" (3 ft.) which are locally changed to anthracite or natural coke by contact with andesite. These seams are, no doubt, continuations of those of the Kurate-Kaho field, which pass Namazuta colliery. The small field west of Iizuka is also a synclinal basin, the axis lying in the eastern part. The workable seam has a thickness of 4 or 5 feet and the coal is generally of good quality. The principal seams outcropping on the south of Iizuka are the "5-foot" (4.5 ft.) and the "4-foot" (3 ft.). Their southern continuations are locally called "8-foot" and "3-foot" seams, and they are frequently disturbed and altered to *senseki.* The collieries are the Tadakuma, Minamio, Hiragaki, Yoshikuma, Aigo, Usui, etc. Further westward near Mameda and Hiratsuka there are four seams of which the "8-foot" (3.5 ft.) and "5-foot (3 ft.) seams are the principal ones.

d. **Western Kaho Region.**—This occupies a small area, situated to the west of the preceding region in the vicinity of Daibu. The workable seams are two, the "3-foot" (2 ft.) and the "5-foot" (3 ft.).

Besides the above coal-fields along the Onga-gawa basin, there are three isolated coal-fields known as the Kasuya, the Kuki and the Munakata.

e. **Kasuya Coal-field.**—This field occupies a small area northwest of the city of Hakata, surrounded by granite and Palæozoic rocks. It may be described, for convenience sake, according to its natural division into a northern and a southern part by the interposed Palæozoic rocks. The seams in the northern field show a general strike changing from N.W. to S.W., and form a syncline. The "3-foot" and the "5-foot" seams (total 5 ft.) are workable. The southern field shows a S.E. strike, and also forms a syncline. It contains a workable seam of from 3 to 5 feet in thickness.

f. **Kuki Coal-field.**—This field occupies a small area in the environs of Kokura, in which the Adachi and Kokura collieries are located. The chief seam is 4 feet thick and forms a syncline with a strike changing from N.E. to N.W.

g. **Munakata Coal-field.**—This is a small area on the north-east of the Tsuri-gawa in Munakata-gōri. The coal-bearing strata are remarkably curved, forming an oblong basin. In the vicinity of Ikeda, there are two workable seams of 3 feet and 4 feet.

Collieries in the Chikuhō Coal-field which produced more than 50,000 tons in 1900 are as follows:—

TAGAWA-GŌRI, BUZEN.

	Tons.
Nara Ōyabu	200,460
Komatsu	178,615
Akaike	168,120
Hōkoku	159,633
Minechi	124,944
Kaneda	118,276
Ida	100,423
Ikejiri	66,809
Kanaya	61,000

ONGA-GŌRI, CHIKUZEN.

Ōtsuji	148,400
Arate	59,697
Ōkuma No. 2	51,002

KURATE-GŌRI, CHIKUZEN.

Shinnyū	282,119
Dainoura	180,326
Yamano	86,546
Katsuno	83,235
Usui	74,940
Hondō	63,974
Mannoura	63,290
Daijo	58,344
Otoku	57,590

KAHO-GŌRI, CHIKUZEN.

Daijō	204,153
Namazuta	133,353
Tadakuma Honami	65,391
Shimo-Yamada	56,713

Coal-fields of Northern Hizen.—Coal-seams are intercalated in the Tertiary strata in Kita-Matsura-gōri, Higashi-Matsura-gōri, Nishi-Matsura-gōri, Kishima-gōri, and Nishi-Sonogi-gōri, in the province of Hizen. The coal seams are generally thin but they are profitably worked in numerous places on account of their good quality and the convenience of transportation.

Collieries in the eastern portion of this district are located chiefly in Nishi- and Higashi-Matsura-gōri and in small portions of Nishi-Matsura-gōri, Ogi-gōri and Kishima-gōri. Coals from Nishi- and Higashi-Matsura-gōri are exported from Karatsu harbour and are known as the Karatsu coals. The principal collieries are the Ōchi, Mutabe, Yoshinotani and Chōja and the workable seams are 7 feet and 3 feet thick. Those of Ogi- and Kishima-gōri are shipped to Nagasaki. The Fukumo, Taku, Kitakata, Kishima, Ichimura and Shiku-Urata are the principal collieries. The coals from these are inferior to Karatsu coals, but being conveniently situated for transprotation, very thin seams are worked. In 1899 there were 38 collieries which produced altogether 479,540 tons.

In the coal regions of Kita-Matsura-gōri and Higashi-Sonogi-gōri which lie westward, the coal-bearing Tertiary shale and sandstone are frequently traversed by basalt dykes. Strike is variable and faults are numerous. In quality the coals are inferior to those of Taka-shima and Karatsu. The thickness of seams does not usually exceed 2 feet, but, being conveniently located for transportion, numerous small collieries have been worked on them. The most productive of these are in the environs of Fuku-shima, Imafuku, Shisa, Emukai, Shikamachi, Kosasa, Minase, and Sasebo. In 1899 there were forty-one collieries that raised more than 1,000 tons, their total production being 139,293 tons.

Matsu-shima Coal-field.—Matsu-shima is a small island in Nishi-Sonogi-gōri. Outcrops of coal are found at several places near the coast of the island. Several seams are known to exist and three seams having a total thickness of about 8 ft. are worked. The total production in 1899 was 26,903 tons.

Coal-field of Taka-shima and adjacent islands.—This is the important coal-field including Taka-shima, Ha-shima, Nakano-shima and Kōyake-jima, outside of the bay of Nagasaki. The coal seams are thick and the coal is of a good quality. The most productive mines are those in Ha-shima and Taka-shima. Taka-shima has thirteen seams of which the upper or "8-foot," the Goma (5 ft.), the Banto (5 ft.), the "3-foot" and the "18-foot" (upper 10 ft. and lower 8 ft.) seams are workable. The seams dip 10°–18° to N.W., and become thinner downwards. In the northeastern part of the island a great fault truncates all the seams. Till recently Taka-shima produced a large amount of coal, but lately the production has become very small. It was 158,247 tons in 1900. The coal seams of Ha-shima and Nakano-shima are much the same as those of Taka-shima but they are more steeply inclined.

Miike Coal-field.—This field occupies an area of about 20 sq. *ri*, extending over Miike-gōri in Chikugo and Tamana-gōri in Higo. The quantity of coal within 1,500 feet below the sea-level is approximately estimated to be 100,005,000 tons. There are eight seams in thick Tertiary sandstone, of which the most valuable are the first "8-foot" and the second "5-foot" seams. They gently dip 6°–8° to S.W. The eastern side of the Tertiary is thrust up and comes in direct contact with the underlying granite. The "8-foot" seam yields the best coal, and often attains a thickness of 20 feet, while the "5-foot" seam which lies from 6 to 10 feet below the former is inferior in quality and is not worked at present. The "8-foot" coal, the Miike coal of the market, is not quite black but grayish; it is a highly bituminous caking coal, with no small proportion of sulphur, and having a great calorific power. In the Asiatic markets it is highly esteemed as a gas- and coke-producing, and an excellent engine coal. The principal collieries are at Ōura, Miyanoura, Nanaura, and Kachidate, and the deepest level has a length of 5,214 feet. The daily output is approximately 2,000 tons, and in production the Miike stands at the head of Japanese coal mines.

Production.

	Tons.
1896	698,480
1897	698,046
1898	612,768
1899	744,026
1900	719,417

SOUTHERN ISLANDS.

Coal-field of the Yaeyama islands.—In Iriomote-shima, one of the Yaeyama Islands in Okinawa Prefecture, there is found a coal seam of 4 feet intercalated in Tertiary shale and sandstone. It is of a fairly good quality, but very limited in extent. The production during the year 1900 was 18,640 tons.

Coal-fields of Taiwan (Formosa).—The coals of Taiwan are found in Tertiary shale. In the northern part of the island numerous coal-seams can be traced from Kiirun to Byō-ritsu. They are for the most part only 1 or 2 feet thick and rarely exceed 4 feet. The strike is N.E. in the northern part, but changes to N.N.E. near Byō-ritsu. The seams form several folds and dip about 30°, rarely less than 20°. They are chiefly worked in the vicinities of Taihoku and Kiirun, and the principal collieries are at Kankyaku, Mokusan, Hatto, Denryōkō and Shikyakutei.

Kankyaku lies north of Suihenkyaku. Four seams are found there, one of which is 5 feet thick; they dip E.S.E.

Mokusan is situated north of Kiirun. The seams are 2 ft. thick and dip 25° E.S.E. They are probably of a higher horizon than those of Kankyaku.

Hatto is to the N.E. of Kiirun. The "3-foot" seam here was formerly worked by the Chinese Government; besides this, two seams, each 1 foot thick, are found. They dip 15° E.S.E.

The Denryōkō colliery lies near Kiirun to the south of Hatto. At this place are found three seams; they dip 25° E.S.E. The lowest is 3 feet thick and is probably identical with the "3-foot" seam of Hatto; and the coals of Hatto and Denryōkō are of a higher horizon than that of Mokusan.

Shikyakutei lies S.S.E. of Kiirun. The seams, higher than those of Denryōkō, form an anticline. The principal seams are three in number, of which the thickest is 4 feet.

The above-mentioned coal-seams extend to Ginaryō and Ryūtanto on the east, and to Dandangai, Suihenkyaku, Nankōshikō, Tōseikaku, etc, on the west. Besides them we find coal seams at Kimpōri, Sanshōrei, Shintengai, etc.

C. LIGNITIC COAL.

Inferior lignite, retaining a woody texture,—locally known as *iwaki,*—occurs either in the upper-most horizon of the Tertiary strata or in the lower part of the Quaternary beds; and it is locally used as fuel. The seams of lignitic coal are mostly thin, rarely exceeding 5 feet. This coal is mined in considerable quantities in the provinces of Owari and Mino, and also occurs in the provinces of Rikuchū, Rikuzen, Kōzuke, Awaji and Shōdo-shima.

D. PEAT.

Peat is found in several places; the principal localities are Akita and Aomori Prefectures, where it is locally called by the name of *nekko* or *gasu.*

III. PETROLEUM.

Outcrops of petroleum are found in several parts of Japan, mostly in Tertiary terranes. Collecting petroleum for use has been in vogue from early times, but the production of it on a large scale was only begun quite recently. Inflammable natural gas occurs also in most petroleum districts, but its utilization is on an insignificant scale, excepting that which issues from petroleum bore-holes. The most productive oil-district is Echigo, and the next Tōtōmi, while Hokkaidō, Ugo, and Shinano yield only a small quantity of petroleum.

According to statistics furnished by the mining associations in Echigo, the production of crude oil in the Empire during the years 1895–1900 was as follows:—

Province.	1895.	1896.	1897.	1898.	1899.	1900.
	Koku.	*Koku.*	*Koku.*	*Koku.*	*Koku.*	*Koku.*
Echigo	152,849	206,033	281,277	318,622	501,561	833,766
Tōtōmi	2,094	2,160	2,710	2,783	2,437	2,715
Other provinces.	—	3	—	1,000	—	17
Total	154,943	208,196	283,987	322,405	503,998	836,498

The total amount of kerosene manufactured may be roughly put as about 40 per cent. of the crude oil produced.

Still it falls far short of the total amount now consumed in the Empire, the greater part of which is imported from the United States, Russia and the Dutch Indies.

The quantity and value of kerosene imported into Japan during recent years are as follows:—

	1895.	1896.	1897.	1898.	1899.
Amount imported (in *Koku*) ...	44,152,414	54,692,886	61,058,217	67,905,455	52,421,838
Value (in *Yen*)...	4,303,929	6,331,036	7,667,350	7,552,879	7,918,149

Usually the Japanese oil is got by means of dug and bored wells, but in rare cases by driving horizontal tunnels into mountain-sides. The depth of the wells varies greatly, and the quantity as well as the quality of oil varies according to the locality and geological horizon of the oil-wells, differences sometimes occurring even in the same horizon.

The deepest productive well ever bored in the country is at Amaze in Echigo. It has a depth of 3,074 feet, and of several oil-beds cut through by it the lowest was met with at 2,400 feet. The next deepest productive well, which is at Miyagawa, in Echigo, reached the depth of 1,440 feet, where the lowest oil-bed of that district was met. Near Gendōji oil is found at the small depths of 120–150 feet. In the other Echigo oil-fields, the depths of wells are commonly between 600 and 900 feet, and in a few regions from 240 to 300 feet.

We shall now proceed to describe briefly the oil-fields of Japan, commencing in the north.

HOKKAIDŌ.

Penkeopirarika, Yuputs-gōri, Iburi.—Outcrops of oil are found on the Penkeopirarika, a tributary of the Mu-kawa. Twelve wells were bored by the *kazusa-bori* method, a simple hand-boring process, between 1891 and

1894. It is said that before an inundation in 1897 the production of oil was more than 40 *koku* per month, but since the inundation the production has greatly decreased. The production in 1900 was about 4 *koku* per month. The depth of the wells varies between 18 feet and 342 feet. The region consists of shale and sandstone, striking nearly N.–S. and dipping westward. The oil is of 43° Baumé and 60 per cent. of it is used for lamp-oil.

Shumbets, Atsuta-gōri, Ishikari.—The oil-field is situated at Shumbets-yama, Mori-mura, to the northeast of Ishikari town, and on the upper course of the Shatskari-gawa. This district consists of sandy shale and dark gray shale occasionally containing nodules of marl. The strata generally strike N.W.–S.E. and gently dip towards S.W. The oil is contained in the shale and there are numerous outcrops in the valley. Since 1879 hand-borings to get the oil have been made, and twenty or thirty wells have been bored, the deepest being about 720 feet. The total production in 1893 was approximately 52 *koku*.

Outcrops of oil are also found in the following localities:

ISHIKARI.

Mōrai, Shatskari and Kotan, Atsuta-gōri.
Nakagoya, Ishikari-gōri.
Etaibets, Uryū-gōri.
Toku-gawa, Kabato-gōri.
Naibets, Sorachi-gōri.
Taru-gawa, Kuttaru-gawa and Kiyom-ap, Yūbari-gōri.
Tsukisap, Satsporo-gōri.

IBURI.

Hayakita, Karumai, Moibets, Mirukunnai, Shoruma, Kabyū and Tonniya, Yūputsu-gōri.

HIDAKA.

Horosaru, Haye and Kenomai, Saru-gōri.

Several places between Atsubets and Porosep, Niikap-gōri.
Yamakoshinai, Yamakoshi-gōri.

OSHIMA.

Nigorikawa and Washinoki, Kayabe-gōri.
Izumisawa and Kodaniishi, Kamiiso-gōri.

NEMURO.

Chyūrui, Menashi-gōri.

UGO.

Nigorikawa, Minami-Akita-gōri.—This field lies about 1 *ri* north of the town of Akita. Since 1873 eighteen wells have been dug. In 1875, when it was most productive, the average daily production was 4 *koku*. But subsequently the output decreased, and in 1900 only 0.4 *koku* daily was got from three or four wells. Here the principal oil-bearing stratum seems to lie at a depth of 192 feet. The stratification is as follows: First, surface soil (6–15 feet), then *aka-iwa* (red rock, 30 feet), and next *awo-iwa* (bluish shale), which is underlaid by a hard sandstone locally known as *kanazaku*.

Izumi, Minami-Akita-gōri.—This place lies a half *ri* from Akita. Since 1878 three wells of the depths of 558, 264, and 588 feet respectively have been sunk here. In 1894 the daily production was about 7 *koku*, and in 1900 only 0.4 *koku*. The first oil stratum was reached at the depth of 198 feet, and the second between 420 and 480 feet. Bluish shale predominates.

Kami-Oguni, Uri-gōri.—Near Hirasawa-mura on the coast of the Sea of Japan seventy shaft-wells have been dug since 1874. They are from 90 to 180 feet deep and the oil beds are generally found below 60 feet. The most productive well once yielded 4 *koku* per day, but nearly all of them have gradually ceased to flow. In 1900, there were only two or three wells yielding a very small quantity. The ground mainly consists of an alternation of shale and sandstone; and the oil-bearing bed is a loose sandstone containing numerous quartz grains.

The petroleum here obtained is very thick, and brown, dark blue or nearly black in colour, and from it 40% or 50% of lamp-oil is obtained.

The other localities where outcrops of oil are found are as follows:

Tsubaki, Menagata, Iwatogawa, Komagata and Kami-Iwakawa, Yamamoto-gōri.
Ogura, Kobayashi, Funabashi, Urayama, Kurokawa, Michikawa, Soyekawa, Kawashiri, Nakamaguchi, Funagawa, Ryūge, Tsukinoki, Kusōdo and Yabase, Minami-Akita-gōri.
Ishidazaka and Toyomaki, Kawabe-gōri.
Yukikawa, Myōgasawa, Katte, Michikawa, Futako, Shimo-Hebita, Kami-Hebita, Kami-Innai, Ryōzenji, Yokooka, Kameda, Ashikawa, Oyagawa, Fukazawa, Kosugeno, Yoshizawa, Kawabe, Sugisawa and Sarukura, Yuri-gōri.
Kusōzu, Atsumi-gōri.

ECHIGO.

The chief oil-fields of Echigo are, in the order of productiveness, the Nishiyama, the Higashiyama, the Niitsu, the Kubiki region (including numerous oil districts of small production in Higashi-, Naka-, and Nishi-Kubiki-gōri); and the fields of lesser importance are the environs of Myōhōji in Kariha-gōri, the environs of Kusōzu in Santō-gōri, and Kurokawa in Kita-Kambara-gōri.

Kurokawa, Kita-Kambara-gōri.—The oil-field lies

5½ *ri* north of the town of Shibata. Hundreds of wells have been dug, but in 1894 the production was only 1 *koku* per day from a few wells. The oil-stratum was generally met with at a depth of something more than 180 feet. Below this the work was prevented by water. The oil is found in a sandstone with a thickness of from 1 to 4 feet. It is overlaid by a thick bed of shale which is occasionally covered by conglomerate. The petroleum is of a dark and thick kind, affording 30% of lamp-oil.

Niitsu, Naka-Kambara-gōri.—Niitsu lies 9 *ri* south of Niigata. The oil of the environs of Niitsu was known in early times and was obtained by means of shaft-wells in Shiotani, Asahi, Kanatsu, etc. In 1891, in Shiotani there were 40 shaft-wells with a combined daily output of 60 to 70 *koku* at depths of less than 250 feet. In 1896, the cheap method of hand boring called *kazusa-bori*, which had been in use for sinking artesian wells in other parts of Japan, was introduced, the result being an increase of production and extension of the field. This most productive oil region now extends over Kumazawa, Soda-yama and Ōkubo in Niitsu and the neighbouring village of Koguchi, besides the old localities. The total daily output from more than 60 wells is a little more than 300 *koku*. The following table shows the annual production in the environs of Niitsu from 1896 to 1900.

	Koku.
1896	6,580
1897	39,170
1898	38,230
1899	45,350
1900	84,271

At present wells are from 360 feet to 720 feet deep, and there are wells that have produced over 100 *koku* a day.

The oil is very heavy, having a gravity of about 19° Baumé, and is very suitable for the manufacture of lubricating oil.

Higashiyama, Koshi-gōri.—The important oil-field known as Higashiyama lies about 3 *ri* east of the town of Nagaoka, in the mountains extending southwards from Niitsu. The productive region extending for about 1 *ri* from north to south is divided into the five districts of Urase, Hire, Katsubo, Katsurazawa and Tsubakizawa; but they are contiguous and can be considered as one. The successful opening of the field dates from 1888. The annual production during recent years has been as follows:

	Koku.
1895	120,396.60
1896	170,701.36
1897	216,366.30
1898	238,953.31
1899	257,072.53
1900	265,050.99

The number of productive wells in the whole region was reported on Oct. 25, 1901 as 233, of which 119 were bored wells and 114 shaft-wells, and the total production for the same day was 982.68 *koku.* Urase and Hire produce about equally and together about two-thirds of the output of the whole field. The two districts lie side by side in the southern extremity of the field, and occupy together the broadest portion of it which is about 700 metres wide. The most productive portion of Higashiyama is in Hire, where many wells, each of which yielded at one time 50 *koku* or more per day, have been bored in the narrow strip of ground owned by the Hōden Oil Company. In the Katsubo region, which lies north of the above, and stands next in importance, there was formerly a shaft-well which produced 100 *koku* per day; numerous shaft-wells exist there closely clustered, which yield on an average 3 *koku* per day. The oil bed, consisting of a loose sandstone, is reached generally at depths of 720 to 840 feet in Hire and the western portion of Urase, of 480 to 540 feet in the eastern portion of Urase, and of 540 to 600 feet in Katsubo, Katsurazawa and Tsubakizawa. The oil region is on an anticline, running nearly north and south, on the top of which is exposed soft bluish sandstone which underlies shale intercalating thick volcanic agglomerate. The following are the records of excavation of two wells in the field:

The Japan Oil Co. well No. 2, situated nearly on the boundary between Urase and Hire, which once yield 100 *koku* per day:

	Feet.
Surface soil...	0— 9
Soft bluish sandstone	9—226
Blue clay	...226—277
Dark sandstone	...277—281
Blue clay	...281—380
Clay with sand	...380—462
White soft sandstone...	...462—602
Hard sandstone	...602—613
White soft sandstone...	...613—726
Reddish sandstone	...726—766
White sandstone (Oil bed) ...	...766—849
Clay with sand	...849—864

Mujin Well, Shinfusō Co., Katsubo:

	Feet.
Bluish sand...	0—210
Bluish shale	...210—300
Bluish sand...	...300—432
White rock...	...432—438
Black shale...	...438—606
Greasy shale	...606—618
Coarse sand (Oil bed)	...618—633

The oil is very heavy, having a gravity of about 19° Baumé, and is very suitable for the manufacture of lubricating oil.

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Mujin Well, Shinfusō Co., Katsubo:

	Feet.
Bluish sand	0—210
Bluish shale	210—300
Bluish sand	300—432
White rock	432—438
Black shale	438—606
Greasy shale	606—618
Coarse sand (Oil bed)	618—633

The oil is rather heavy, the density ranging between 27° and 35° Baumé, and contains about 50% of lamp oil. Hire produces the best oil, and Urase the second best, and the quality of the oil gets worse as we proceed northward.

Takezawa, Koshi-gōri.—About 4 *ri* south of the south end of the Higashi-yama field and in the same range of mountains lies the small oil district of Takezawa. At the most productive period, in 1894, about 20 oil-wells had been dug and the whole yield was about 2 *koku* a day. In 1901 an insignificant quantity of about one-fifth of a *koku* per day was raised from two wells. The rock consists mainly of shale. The gravity of the oil is 39° Baumé and it is of a good quality.

Amaze, Santō-gōri.—Amaze, adjacent to the town of Izumozaki, lies on the coast of the Sea of Japan. Beginning in 1873 wells were at first dug on the slope of the hill east of Amaze. They were not deeper than 540 feet and yielded only about 3 *koku* a day. In 1883, a well was tried on the beach and it proved to be very successful. Many shaft-wells have been dug since that time along the coast, and in 1890 there were more than 150 wells. Up to that time, however, wells could not be dug deeper than 480 feet, owing to the issuing of saline water below that depth. In 1890 this difficulty was overcome by the introduction of the American system of boring, and derricks were erected on the sea. The field was in its most prosperous condition in 1894 and 1895, and after that time the production gradually decreased. Since the discovery of the Kamada-Nagamine field, the Amaze field has been almost neglected. The following table shows the output since 1886.

	Koku.
1886	292
1887	2,542
1888	8,863
1889	15,868
1890	10,436
1891	7,523
1892	5,863
1893	18,432
1894	34,291
1895	25,178
1896	17,694
1897	13,830
1898	13,407
1899	7,011
1900	5,764

The depths of the bored wells in this field ranged between 1500 feet and 2562 feet. The best well was No. 6 of the Japan Oil Company. It was 311 *ken* deep and produced 11,000 *koku* of oil from February 1894 to June 1899. The rocks consist mainly of shale alternating with sandstone and generally dip gently S.E. The oil strata occur in several horizons and the uppermost is only from 30 to 36 feet from the surface. The well No. 13 of the Japan Oil Company penetrated thirteen oil strata within 2100 feet. The oil-content varies with horizons and generally speaking is larger in the deeper beds. A few spouting wells have been bored in this field. The petroleum is of a very good quality, yielding 80% of lamp oil.

Kusozu and Ushirodani, Santō-gōri.—About 1½ *ri* southeast of Izumozaki, is Oginojō-yama. The village of Kusōzu on the western side of this mountain was known in early times to produce mineral oil. The wells are excavated upon a steep anticline formed of strata which resemble very closely those in Amaze. The strata consist essentially of gray, soft shale with subordinate sandstone. The oil bed, which is a loose sandstone, lies between the depths of 60 feet and 100 feet, and always contains gas. The deepest well ever dug here is 360 feet deep. Sixty or seventy years ago petroleum was got by excavating horizontal tunnels near oil seepages. Subsequently to the Zenkōji Earthquake in 1847, the oil ceased to flow, but four or five years later it reappeared and numerous shaft-wells have since been dug. The most productive time was during 1872–1874, when the daily output approached a hundred *koku*. One of the wells is said to have then yielded 50 *koku* in a day, although for only a short period. In 1899, however, the oil production decreased so much that many of the wells were abandoned, and only 2 *koku* daily were gathered from three wells, not deeper than 300 feet, and six tunnels. The oil is light, and it is said that 70% of lamp-oil is obtained.

Ushirodani is situated southeast of Kusōzu and on the other side of Oginojō-yama. In 1899, there were some six *kazusa-bori*-wells about 700 feet deep, producing 10 *koku* a day. The spot lies on an anticline with N.E. strike and a gentle dip.

Myōhōji, Kariha-gōri.—This is situated 6 *ri* north-east of Kashiwazaki town. From three hundred and forty years ago until about eighty years ago, when wells were first dug for the oil, petroleum had been collected from outcrops at this place. The industry has continued since, and in 1887 when it was most prosperous the daily production reached about 10 *koku* a day. But the production afterwards gradually decreased, and in 1901 the field was in such a deplorable condition that only 15 *koku* was obtained from some nine wells in a month.

The oil-bearing strata consist chiefly of shale intercalated with sandstone. The strata strike in general N.N.E. and dip highly toward W.N.W. Profitable oil-beds are generally located at depths of more than 420 feet, and are mostly near 600 feet. The oil is of a good quality and about 80 per cent. of it is said to be available as lamp-oil.

In the neighbourhood of Myōhōji are the now abandoned oil districts of Betsuyama, Tozawa, Sakata, Ōtsubo, and Akata.

Nishiyama Oil-field, Kariha-gōri.—This oil-field lies north-east of the town of Kashiwazaki, and near the coast of the Sea of Japan. The productive districts are Nagamine, Kamada, Miyagawa and Ushirodani.

Kamada and Nagamine.—These two districts are continuous and form the most productive oil region in Japan. The opening of the region, Nagamine in 1898 and Kamada in 1899, gave a strong impulse to the petroleum industry of Japan. The following table gives the production of the two districts separately:

Kamada.

	Koku.
1899	16,701.20
1900	172,392.68

Nagamine.

	Koku.
1898	23,486.44
1899	171,899.69
1900	303,427.46

The number of producing wells on Oct. 25, 1901, is reported to have been 346 in Kamada and 61 in Nagamine, all the wells being bored wells, and the production for the day 358.7 *koku* in Kamada and 1,366.7 *koku* in Nagamine.

Kamada extends to Nagamine in a south-westerly direction and the whole length of the productive field measures

1800 metres and the breadth 400 metres. The productive portions lie on the top of an anticline with gentle dip running in the direction of the longer axis of the field. The first productive oil bed is found in a fine-grained sandstone at a depth of about 600 feet. A few wells are deeper than 1,000 feet. Gas is plenty in the field and many wells have been bored which spouted intermittently at first and afterward flowed quietly, the yield of oil being not rarely over 100 *koku* per day. In Kamada, the production of each well decreases more rapidly than in Nagamine, probably owing to the wells being too close together.

The following are the boring-records of two wells in the field.

Japan Oil Co., well No. 1, Nagamine.

	Feet.
Clay	0— 27
Bluish soft sandstone	27— 43
Shale	43— 90
Sandy shale	90—108
Shale	108—128
Bluish soft sandstone	128—156
Shale	156—186
Bluish soft sandstone (Oil indication)	186—306
Shale	306—348
Bluish soft sandstone	348—384
Shale	384—444
Bluish soft sandstone (Gas)	444—528
Shale	528—552
Gray clayey sandstone (Oil bed)	552—600

Zaō Oil Co., well No. 1, Kamada.

	Feet.
Surface soil	0— 57
Sandy shale	57— 99
Fine sandstone	99—108
Sandy shale	108—120

	Feet.
Fine sandstone	120—155
Sandstone (indication of oil)	155—177
Conglomerate	177—186
Fine sandstone	186—213
Alternation of sandstone and shale	213—280
Shale	280—312
Sandy shale	312—357
Conglomerate	357—372
Sandstone	372—402
Sandy shale	402—528
Shale	528—564
Hard sandstone	564—582
Fine clayey sandstone (Oil and Gas bed).	582—646

The crude oil is heavy, the average density for Kamada being 22.2° Baumé and for Nagamine 28.2° Baumé.

Miyagawa and Ushirodani.—These two districts are also continuous and are situated westward of Nagamine near the village of Miyagawa on the coast. The first successful boring was made in Miyagawa in 1894. There are nine bored wells in the region from which about 50 *koku* are obtained daily. The productive oil beds lie 1,200–1,380 feet deep. The strata dip gently south in Miyagawa, and dip N.W. in Ushirodani. The following is the record of the well No. 2 of the Japan Oil Co.

	Feet.
Clay	0— 75
Shale	75— 180
Gravel	180— 300
Shale	300— 420
Gravel	420— 450
Soft sandstone	450— 516
Shale	516— 570
Sandstone	570— 684
Gray sandstone	684— 933
Shale	933—1,044

	Feet.
White sandstone	...1,044—1,056
Shale	...1,056—1,104
Bluish hard sandstone... ...	...1,104—1,170
Shale	...1,170—1,215
Coarse sand (Oil bed)... ...	...1,215—1,260
Shale	...1,260—1,278

The oil is comparatively light, being of the average density of 30.2° Baumé.

Oil-fields of Higashi-Kubiki-gōri.—*Environs of Matsudai.*—Matsudai lies in the eastern part of Higashi-Kubiki-gōri. It is an old oil district. About twenty-two years ago there were some twenty wells, one of which yielded 1 *koku* of oil per day. At present it is almost abandoned. Natural gas is found here.

Ōarato and Kodani south of Matsudai were most prosperous in 1876 and there were many very shallow productive wells. But the production is now insignificant. The oil strata are here shale or hard sandstone, and there are many horizons of them. The oil is good and about 85 per cent. of it is obtained as lamp-oil and 10 per cent. as volatile oil.

Seepages of oil are found in several localities in the Sakashita region south-east of Ōarato. There are some twelve wells with a small production of oil.

Gimyō, west of Matsudai, lies 2½ *ri* east of Yasuzuka. From 1887 to 1890 the yield from more than twenty wells was 3 *koku* a day. In June 1899, there were seven wells not deeper than 372 feet, producing 0.15 *koku* in a day.

The oil-bearing strata consist mainly of gray shale and they form an anticlinal fold, running N.E.–S.W. At present the upper oil-beds are found dry, and the productive strata lie below 120 feet and usually at about 240 feet.

Near Gimyō are the oil districts of Kiwada, Nataira, Koike, and Murono, which now produce either no oil or quite an insignificant quantity.

Environs of Iwagami.—The oil region near Iwagami is located 3½ *ri* south-east of Takata. In 1880 there were more than 100 wells, producing more than 10 *koku* in a day. Their depths were from 120 to 138 feet. In August 1899, there were only 7 wells yielding about 40 *koku* per month.

The oil-bearing strata are chiefly shale with grayish green sandstone. The oil-beds, which consist of a grayish-green, fine sandstone, usually not thicker than 2 feet, are found at various depths below 120 feet, but those at present productive are below 300 feet.

Oil-fields of Naka-Kubiki-gōri.—The oil region of Naka-Kubiki-gōri lies 2½ *ri* south-east of the town of Takata and is one of the oldest oil-producing localities. The collection of oil by digging shallow wells was practiced two hundred years ago, and before the discovery of the Higashi-yama oil-field, this field and that of the Myōhōji region were the most productive in Echigo. But the production gradually decreased, until a new impetus was given to the industry by the discovery of the Kitano field in September, 1900, in this region. The oil from this region is light and 80 per cent. of lamp-oil is usually obtained from it. The present total output from some 240 wells excluding the Kitano wells is said to be about 260 *koku* per month.

Kitano.—Kitano lies south of the abandoned oil districts of Hirugo and Higashi-Tono. The first successful well struck in the new field of Kitano yielded over 100 *koku* a day in the very beginning, but the output rapidly declined. Other wells have been opened in succession in the neighbourhood. The total quantity obtained from eight wells during the half-year from April to September, 1901, was 7,792 *koku.* Oil has been found at a depth of about 700 feet. The crude oil is of 36° Baumé.

South of Kitano are found the two important old oil-districts of Gendōji and Tateno.

Gendōji Region.—This region lies 2½ *ri* south-east of Takata. It comprises the three neighbouring districts of Ōgidaira, Gendōji and Maya. Ōgidaira produces per month about 30 *koku* of oil from sixteen wells 240–600 feet deep. When it was at the height of its prosperity during the years from 1877 to 1880, there were 260 wells with a monthly production of 1,200 *koku* or more. In Gendōji, separated by a small valley from Ōgidaira, the monthly output was in August, 1899, 100 *koku* from 12 wells. Gendōji was most prosperous about 1884 when it produced 1000 *koku* per month. There were in Maya in August, 1899, thirty wells which yielded altogether 130 *koku* per month. Maya produced 600 *koku* per month when it was most prosperous about 1880. The rock in these regions is chiefly shale; the strata strike N.E.–S.W. or E.–W., and dip southwards. Landslips are frequent. The oil strata are fine, gray tufaceous sandstone and coarse, green sandstone, and they lie in several horizons, all deeper than 60 feet. The present productive beds lie between 420 feet and 540 feet in Ōgidaira, between 700 feet and 780 feet in Gendōji, and below 720 feet in Maya. The oil is very good, of the density of 40° Baumé.

Tateno Region.—The Tateno region lies 2½ *ri* south-east of the town of Takata. It was here that the digging for petroleum was first tried in Naka-Kubiki-gōri. About 35 years ago, at its most prosperous time, the monthly production reached 700 or 800 *koku*. In August, 1899, it was estimated at only 20 *koku*. There were then sixty wells, and none deeper than 720 feet. The strata mainly consist of shale, and the oil is contained in sandstone interstratified with it. The strata strike generally E.N.E. and dip gently

S.S.E. The uppermost oil bed is found at the shallow depth of 18–24 feet, and is said to have produced a moderate quantity of petroleum in former times. A few years ago the oil was drawn out of a bed situated at the depth of 120 feet, but now it is commonly obtained from a depth greater than 300 feet.

Oil-field of Nishi-Kubiki-gōri.—*Higashi-Hiyama.*—This district is situated on the upper course of the Nadachi-gawa and is 3 *ri* distant from the town of Nadachi. The oil collecting began in 1879 and since then about fifty wells have been opened, their depth being 360–990 feet. The best of them produced about 20 *koku* a day and there were several that yielded 3 or 4 *koku*, but afterward the production gradually diminished and the greater part of the wells have been abandoned. In October, 1897, only eleven wells were productive, daily yielding 5 *koku* altogether.

The strata, consisting of an alternation of sandstone and shale, dip highly towards E.S.E. The principal oil beds are generally found below 360 feet and are mostly bluish, fine grained sandstone. The oil is of the density of 37.5° Baumé.

In the upper part of the Nō valley 1½ *ri* south-west of Higashi-Hiyama, old abandoned wells are found at Mizoo and Maki-mura.

SHINANO.

Oil-field of Tomikura, Shimo-Minochi-gōri.—The field is situated near the boundary of Shinano and Echigo, northwest of Iiyama town. The digging began in 1871, and in 1879 there were at Matsuzawa nine wells, none of which were deeper than 570 feet, and which yielded 11,664 *koku* from 1871 to 1883, when they were abandoned. Besides, numerous wells were opened at Nakano, Nigoriike and other places, but all of them were abandoned. A bluish, loose sandstone occurs at the depth of 9 feet and next comes a blue shale overlying a second bluish sandstone, which bears the oil.

Oil-field of Saijo, Kami-Minochi-gōri.—This field lies 1 *ri* north of Nagano, and extends over Saijō, Shisarishinkōji, Uyematsu, etc. In former times numerous wells were dug and yielded some quantity of oil. At present only seven wells are found at Shisarishinkōji. They are not deeper than 300 feet and produce about half a *koku* a month. The rocks are mainly black shale and the oil is found in places near the contact with liparite.

TŌTŌMI.

Oil-field of Sugegaya, Haibara-gōri.—The small oil-field of Sugegaya lying 1 *ri* southwest of the town of Sagara produces most oil outside of Echigo. The oil industry here was begun in 1873, and in the years 1878 and 1879, when the field was most productive, the monthly yield exceeded 3,000 *koku*. But afterward the production gradually declined, and in 1895, the monthly production was reduced to about 280 *koku*, although there remained about a hundred wells. The deepest of these wells is 750 feet deep. About 65 per cent of the oil may be used as lamp oil. The oil bed is fine-grained, loose sandstone less than 3 feet in thickness; sometimes oil is obtained from shale. The strata of shale dip northwestward, generally at high angles. The strata are folded in many small anticlines in the neighbourhood, and outcrops of oil are found in several localities besides Sugegaya.

TAIWAN.

The occurrence of petroleum at Shukkōsha near Byōritsu in the northern part of the island was known from early times and some digging was done. Recently two new localities in the east of Tainan were found. They are Kōnaishō near Tapanii and a region on the Namasen-kei, a tributary of the Katansui-kei. None of them are productive at present.

IV. ASPHALT.

Asphalt is found in Minami-Akita-gōri, Ugo Province, on very gentle hill-slopes underlying the villages of Ryūge and Tsukinoki. There it occurs in the solid form under thin soil and clay apparently covering Tertiary strata, and also in the semifluid form in small ponds and rice fields on the slopes.

V. AMBER.

Amber has been known from early times to occur at Ōkawame in the neighbourhood of the town of Kuji, Rikuchū. It is locally called "Kurinogo," and it occurs in masses of various sizes. Besides, it is occasionally found in the lignite of the Iwaki region; it is there granular and of the size of peas.

VI. STONE FOR BUILDINGS AND MONUMENTS.

The Triassic slate of northeastern Rikuzen, locally known by the name of "Genshō-seki," the Cretaceous Izumi sandstone, and various kinds of Tertiary sandstones are among the important sedimentary rocks useful for building and decorative purposes. For gravestones and monuments the rocks of common occurrence are used, such as granite in Chūgoku, and andesites, tuffs and Triassic slate in Tōkyō and the northern parts of Japan.

The building stones most widely used in Tōkyō are andesites and their tuffs and breccias, which are brought from the peninsulas of Awa and Izu. Granite is much more seldom used in Tōkyō, it being transported from Hitachi, Mikawa, and provinces on the Inland Sea.

Ornamental stones are granite, diorite, porphyrite, serpentine, limestone, schalstein, obsidian, agate and quartz, but these are of limited distribution. The Carboniferous limestone of Mino, the crystalline limestone of Nagato and Hitachi, and the serpentine of Higo and Hitachi are the most beautiful among the ornamental stones.

The following are the chief localities of building and decorative stones:

Schists:	Shimozato, Hiki-gōri, Musashi.
	Sako, near Tokushima, Awa in Shikoku
	Shimoura, Myōsai-gōri, „ „ „
	Nishibayashi, Awa-gōri, „ „ „
Limestone:	Mayumi, Taga-gōri, Hitachi.
	Sukegawa, „ „
	Suwa, „ „
	Tadaki, Inasa-gōri, Tōtōmi.
	Akasaka, Fuwa-gōri, Mino.
	Akiyoshi, Mine-gōri, Nagato.
	Kōchi, Tosa.
Siliceous slate:	Nachi, Higashi-Muro-gōri, Kii.
Sandstone:	Shiratsuchi, Iwaki-gōri, Iwaki.
	Sukagawa, Iwase-gōri, Iwashiro.
	Ida, Chichibu-gōri, Musashi.
	Amenomiya, Suchi-gōri, Tōtōmi.
	Unuma, Inaba-gōri, Mino.
	Misato, Ano-gōri, Ise.
	Tannowa, Izunami-gōri, Izumi.
	Kimachi, Yatsuka-gōri, Izumo.
	Fukui, Mihara-gōri, Awaji.
	Amano, „ „
	Nakasuji, „ „
	Minato, „ „
	Kitatomari, Itano-gōri, Awa in Shikoku.

Yamaga, Onga-gōri, Chikuzen.
Ōkuma, Kaho-gōri, „
Meihama, Sawara-gōri, „
Kusubobaba, Amakusa-gōri, Higo.
Shimoura, „ „
Conglomerate : Akutsu, Higashi-Oitama-gōri, Uzen.
Teshima, Shōdo-gōri, Sanuki.
Tuff : Fukuyama, Matsumae-gōri, Oshima.
Kumade, Higashi-Tagawa-gōri, Uzen.
Ashino, Nasu-gōri, Shimotsuke.
Karasuyama, „ „
Kanuma, Kami-Tsuga-gōri, „
Takegaoka, Kimitsu-gōri, Kazusa.
Kanaya, „ „
Takasaki, Awa-gōri, Awa in Honshū.
Shimosakuma, „ „ „ „
Iwaibukuro, „ „ „ „
Iriyamazu, „ „ „ „
Nanasawa, Aikō-gōri, Sagami.
Shige, Suntō-gōri, Suruga.
Kuchino, „ „
Tai, „ „
Sawada, Kamo-gōri, Izu.
Fukui, Echizen.
Ōshiko, Innami-gōri, Harima.
Yushima, Kinosaki-gōri, Tajima.
Engoji, Iwami-gōri, Inaba.
Arashima, Nogi-gōri, Izumo.
Yokoyama, Kume-gōri, Mimasaka.
Ōtani, „ „
Granite : Matsuda, Ashikaga-gōri, Shimotsuke.
Nagusa, „ „
Kamisaya, Niibaru-gōri, Hitachi.
Iwamakamigō, Nishi-Ibaraki-gōri, Hitachi.
Yamanō, Makabe-gōri, Hitachi.
Motogi, „ „
Hongō, Tsukuba-gōri, „
Nagai, „ „

	Ota, Tsukuba-gōri, Hitachi.
	Iwakura, Higashi-Kamo-gōri, Mikawa.
	Nakamura, „ „
	Kugyūdaira, „ „
	Akahara, „ „
	Akatsu, Higashi-Kasugai-gōri, Owari.
	Kami-mizuno, „ „
	Kaizu, Takashima-gōri, Ōmi.
	Chōfukuji, Gamō-gōri, „
	Tabika, Asake-gōri, Ise.
	Araki, Ayama-gōri, Iga.
	Terada, „ „
	Shūgakuin, Odagi-gōri, Yamashiro.
	Sumiyoshi, Muko-gōri, Settsu.
	Yagi, Funai-gōri, Tamba.
	Waki, Yosa-gōri, Tango.
	Inujima, Oku-gōri, Bizen.
	Hikijima, Bitchū.
	Mukōjima, Bingo.
	Murō, Shōdo-gōri, Sanuki.
	Karahitsu, Kida-gōri, „
	Mukōjima, Kagawa-gōri, Sanuki.
	Ijima, „ „
	Kashiwajima, „ „
	Ōshima, Iyo.
	Nishikawa, Kurate-gōri, Chikuzen.
Diorite :	Kurama, Odagi-gōri, Yamashiro.
Quartz-porphyry :	Mitsuya, Inukami-gōri, Ōmi.
	Kiyosaki, „ „
Serpentine :	Machiya, Kuji-gōri, Hitachi.
	Kamesaku, „ „
	Takanuki, „ „
	Ōkaneda, Taga-gōri, „
	Fujiwara, Tone-gōri, Kōzuke.
	Naruse, Iruma-gōri, Musashi.
	Kanasaki, Chichibu-gōri, „
	Nakamura, Asago-gōri, Tajima.
	Shimogō, Shimo-Mashiki-gōri, Higo.

Liparite:	Hizawa, Kita-Kanra-gōri, Kōzuke.
	Ōshiko, Innami-gōri, Harima.
	Takaya, Kinosaki-gōri, Tajima.
Andesite:	Sukagawa, Iwase-gōri, Iwashiro.
	Shirakawa, Nishi-Shirakawa-gōri, Iwaki.
	Kami-Satomi, Usui-gōri, Kōzuke.
	Higashi-Satomi, „ „
	Akima, „ „
	Nakanomachi, Shimo-Takai-gōri, Shinano
	Nishi-Nagano, Kami-Minochi-gōri, „
	Shiga, Kita-Saku-gōri, Shinano.
	Arakoda, „ „
	Irisawa, Minami-Saku-gōri, „
	Nebukawa, Ashigara-Shimo-gōri, Sagami.
	Enoura, „ „
	Monkawa, „ „
	Iwamura, „ „
	Manazuru, „ „
	Yoshihama, „ „
	Shishihama, Suntō-gōri, Sagami.
	Kuchino, „ „
	Tokura, „ „
	Kanuki, „ „
	Satogaki, Nishi-Yamanashi-gōri, Kai.
	Kōun, „ „
	Kita-ema, Tagata-gōri, Izu.
	Futto, „ „
	Yawatano, „ „
	Akazawa, „ „
	Kami-Tai, Kida-gōri, Sanuki.
	Mitani, „ „
	Asano, Kagawa-gōri, „
	Funaoka, „ „
	Shimabara, Takaku-gōri, Hizen.
	Tobidake, Amakusa-gōri, Higo.
	Takamokujima, „ „
	Iso, Kagoshima-gōri, Satsuma.
Basalt:	Gembutō, Kinosaki-gōri, Tajima.

Nagasato, Kita-Takaku-gōri, Hizen.
Ogawaraura, „ „
Izaki, „ „

VII. CLAYS AND NATURAL CEMENTS.

Fuller's Earth.—Fuller's earth is sometimes found in tufaceous shale, liparite, and liparitic tuff of the Tertiary age; but the beds of the earth are not thick enough for profitable working. Fuller's earth occurs in the following places:

Ōgamo, Kamo-gōri, Izu.
Morimachi, Suchi-gōri, Tōtōmi.
Kadota, Jōdō-gōri, Bizen.
Mishima, Tsukubo-gōri, Bittchū.

Porcelain Clay.—As the potash-feldspar-bearing rocks, such as granite, porphyry and liparite, are widely distributed in Japan, the argillaceous materials for the manufacture of porcelain and earthenware are of abundant occurrence. The porcelain clays of Yamashiro, Ōmi and Owari are the products of decomposition of granite and porphyry, and those of Amakusa, Arita and Izushi come from weathered liparite. Less commonly decomposed sedimentary rocks are used for the same purpose, as in "Bizen-yaki" and "Banko-yaki."

The known deposits of porcelain clay and potter's earth are in the following localities:

Takiyama, Minami-Murayama-gōri, Uzen.
Hongō, Ōnuma-gōri, Iwashiro.
Hachiman, Kita-Aizu-gōri, „
Tsubota, Futaba-gōri, Iwaki.
Kinose, Kōga-gōri, Ōmi.
Asamiya, „ „
Nishimura, „ „
Kutani, Yenuma-gōri, Kaga.

Seto, Kasugai-gōri, Owari.
Chita-gōri, Owari.
Hatsu, Mie-gōri, Ise.
Marubashira, Ayama-gōri, Iga.
Kanamaru, Kashima-gōri, Noto.
Imayama, Sōraku-gōri, Yamashiro.
Mihara-gōri, Awaji.
Tsuna-gōri, „
Izushi, Izushi-gōri, Tajima.
Matsuye, Yatsuka-gōri, Izumo.
Daitō, Ōhara-gōri, „
Isogami, Oku-gōri, Bizen.
Mushiage, „ „
Tasuki, Toyora-gōri, Nagato.
Nanakuma, Sawara-gōri, Chikuzen.
Yoshimatsu, „ „
Koishiwara, Asakura-gōri, „
Arita, Nishi-Matsura-gōri, Hizen.
Gotō islands, Hizen.
Amakusa-gōri, Higo.
Buihara, Yatsushiro-gōri, Higo.
Futami, Ashikita-gōri, „
Ibusuki, Ibusuki-gōri, Satsuma.
Kawanabe, Kawanabe-gōri, „

Fire Clay.—A hydrous silicate of alumina, sometimes known as "Rōseki" in Chūgoku, occurs either as veins cutting acid volcanic rocks or imbedded in tufaceous rocks. Localities are as follows:

Uchigō, Iwaki-gōri, Iwaki.
Mitsuishi, Wake-gōri, Bizen.

"*Tataki*" *Earth.*—*Tataki* is a kind of concrete, in which a natural mixture of sand and earth, (formed by decomposition of granite or sandstone and clayslate, in such a stage of weathering that the feldspar in the rock can be dissolved most effectually by hydric chloride, though it is not completely kaolinized), is cemented with lime. The chief localities are

Maruyama, Niwa-gōri, Owari.
Obuke, Mie-gōri, Ise.
Koshinowara, Yasu-gōri, Ōmi.
Okayama, Gamō-gōri, „
Environs of Kyōto, Yamashiro.
Futsukaichi, Aki-gōri, Aki.
Toyora, Toyora-gōri, Nagato.

Natural Cement.—A certain variety of marl or calcareous clay can be converted into cement by roasting and is known as natural cement. For the manufacture of a cement of good quality, however, it is necessary to have a certain quantity of clay and lime added to the quarried earth. The localities of such earth are

Tomari, Tonami-gōri, Etchū.
Unami, „ „
Yushima, Amakusa-gōri, Higo.
Saizu, „ „

VIII. PRECIOUS STONES.

Malachite crystal, amethyst, smoky quartz and agate were the chief minerals known as jewels to the ancients. The ruby, sapphire, beryl and topaz have become known in comparatively recent times. Tourmaline, axinite, garnet, vesuvianite, etc. are also found, but they are neither fit for ornamental purposes nor abundant. These minerals occur in pegmatitic dykes or in sedimentary rocks metamorphosed by granite intrusion. Agate and opal occur filling cavities in volcanic rocks. Obsidian which is found in abundance, is sometimes used for ornaments.

The following are the chief localities of precious stones in Japan:

Sapphire :	Tadachi, Nishi-Chikuma-gōri, Shinano.
	Hirukawa, Ena-gōri, Mino.
Ruby :	Kiura, Ōno-gōri, Bungo.
Beryl :	Tadachi, Nishi-Chikuma-gōri, Shinano.
	Naegi, Ena-gōri, Mino.
	Sekinotsu, Kurimoto-gōri, Ōmi.
Topaz :	Tadachi, Nishi-Chikuma-gōri, Shinano.
	Naegi, Ena-gōri, Mino.
	Tanokamiyama, Kurimoto-gōri, Ōmi.
	Ishikure, Inabe-gōri, Ise.
Garnet :	Wadatōge, Ina-gōri, Shinano.
	Yamanō, Makabe-gōri, Hitachi.
Opal :	Minowa, Date-gōri, Iwashiro.
	Ishikawa, Ishikawa-gōri, Iwaki.
	Yamanō, Makabe-gōri, Hitachi.
	Kimpuzan, Kai.
	Tateyama, Kami-Niikawa-gōri, Etchū.
	Natani, Enuma-gōri, Kaga.
Blue Tourmaline :	Tadachi, Nishi-Chikuma-gōri, Shinano.
Axinite :	Obira, Ōno-gōri, Bungo.
Vesuvianite :	Kiura, „ „
Malachite :	Kamioka, Yoshiki-gōri, Hida.
	Kiura, Ōno-gōri, Bungo.
Rock Crystal :	Miyamoto, Naka-Koma-gōri, Kai.
	Kimpuzan, Kai.
	Chiyoda, Nishi-Yamanashi-gōri, Kai.
	Takayama, Ena-gōri, Mino.
	Ishikure, Inabe-gōri, Ise.
	Nita-gōri, Izumo.
	Hino-gōri, „
Chalcedony :	Horozuki, Higashi-Tsugaru-gōri, Mutsu.
	Tsukibuse, Sado-gōri, Sado.
Agate :	Tonami-gōri, Etchū.
	Mitsura, Fugeshi-gōri, Noto.
	Tamatsuri, Itō-gōri, Izumo.
	Yumachi, „ „

IX. ABRASIVE MATERIALS.

We shall place abrasive materials in two classes; one consisting of stones, such as are used for millstones, mortars, hones, or whetstones, and the other comprising powders or sands, such as garnet sand, pumice sand, diatom earth, and ochre. For millstones and mortars, compact varieties of granite, diorite, andesite or basalt are chiefly used. The *nagura-do* of Mikawa is a well-known material for hones for swords, being a fine-grained tuff of liparitic rock.

The only abrasive material for hard stones in Japan is garnet sand. It is used for grinding quartz, agate, jade or stones of similar hardness. Ochre and *tonoko* derived from decomposed clayslate, are applied to the polishing of metals. Diatom earth which occurs imbedded in the Tertiary and Quarternary formations, ranks next in importance to garnet sand as a polishing material. Bōshū sand which occurs in abundance in Bōshū or Awa in Honshū, is the sand derived from a pumiceous tuff; it is largely used for the polishing of moderately hard materials.

The following are the chief localities of abrasive materials in Japan:

Millstones and mortars:	Makuraze, Kanoashi-gōri, Iwami.
Grindstones:	
Mica-schist:	Kiya, Sōraku-gōri, Yamashiro.
Adinole-slate:	Saga, Kadono-gōri, „
	Mumegahata, „ „
Adinole-slate and Clayslate:	Miyasaki, Minami-Kuwada-gōri, Tamba.
	Hienota, „ „
	Higashi-Motomume, Funai-gōri, „
	Gomazato, Funai-gōri, Tamba.
	Yagi, „ „
Clayslate and Shale:	Izuchi, Minami-Tsugaru-gōri, Mutsu.
	Kazama, Higashi-Murayama-gōri, Uzen.

	Niwasaka, Shinobu-gōri, Iwashiro.
	Ōizumi, Nishi-Ibaraki-gōri, Hitachi.
	Naganuma, Ōku-gōri, Bizen.
	Kaifuna, Shimo-Agata-gōri, Tsushima.
Schalstein :	Sukegawa, Taga-gōri, Hitachi.
Sandstone :	Takakami, Unakami-gōri, Shimōsa.
Tuff :	Kawai, Kita-Shidara-gōri, Mikawa.
Granite :	Haguro, Nishi-Yatsushiro-gōri, Kai.
Liparite and Dacite :	Tozawa, Kita-Kanra-gōri, Kōzuke.
	Mihara, Kinosaki-gōri, Tajima.
	Kamimura, Amakusa-gōri, Higo.
	Takahama, „ „
Garnet sand :	Ōyachi, Asake-gōri, Ise.
	Anamushi, Kita-Katsuragi-gōri, Yamato.
	Saga, Ōshima-gōri, Suō.
Bōshū sand :	Ōta, Kuji-gōri, Hitachi.
	Ōhata, Awa-gōri, Awa.
	Koromo, Nishi-Kamo-gōri, Mikawa.
	Ogawa, Chita-gōri, Owari.
	Rengeji, Kuwana-gōri, Ise.
	Ishiki, Kagoshima-gōri, Satsuma.
Tonoko :	Udano, Kadono-gōri, Yamashiro.
	Nishinoyama, Uji-gōri, „
Ochre (*Taisha*) :	Sakamoto, Kawakami-gōri, Bitchū.
Diatom earth :	Abashiri, Abashiri-gōri, Kitami.
	Nishio, Kuma-gōri, Higo.
Pumice :	Niijima, Izu.
	Mikomotojima Izu.
	Takasegawa, Tamana-gōri, Higo.
	Miyakonojō, Kita-Morokata-gōri, Hyūga.

X. MATERIAL FOR INKSTONES, OR "SUZURI-ISHI."

The *suzuri* which serves for the grinding of solid Chinese ink, is exclusively used in Eastern Asia. It is made of shale, clayslate or schalstein of a compact and homogeneous texture. Liparite, though very rough in comparison with these, is yet used for the same purpose in schools of lower grades because of its cheapness. It is known by the name of *tora-ishi* or tigerstone, for the rock has usually brown bands in a yellow ground. Inkstones are made from stone quarried at the following localities:

Gosho, Minami-Iwate-gōri, Rikuchū.
Okachi, Momō-gōri, Rikuzen.
Suzurijima, Minami-Koma-gōri, Kai.
Terabayashi, Minami-Shidara-gōri, Mikawa.
Hirose, Takashima-gōri, Ōmi.
Shimbō, Onyū-gōri, Wakasa.
Kami-Saga, Kadono-gōri, Yamashiro.
Morihiro, Asa-gōri, Nagato.
Usa, Takaoka-gōri, Tosa.
Kitagawa, Higashi-Usuki-gōri, Hyūga.

XI. SLATES.

Lydian Stone.—A hard and compact siliceous shale is used as touchstone, and also serves as the material for black pieces in the *go* game. The best Lydian stone known as *nachi-guro* comes from Nachigawa, Higashi-Muro-gōri, Kii.

Slate.—A certain kind of slate in Palæozoic and Mesozoic formations is used for roofing and also for school-slates. The chief localities of such slate are as follows:

Okachihama, Momō-gōri, Rikuzen.
Ikawa, Abe-gōri, Suruga.
Shimonokae, Hata-gōri, Tosa.

Lithographic Stone.—A marly limestone of the Tertiary formation can be used in lithography. It is, however, not compact enough to serve for minute printing. The occurrence of the rock is limited to the following two localities:

Sannai, Nishi-Tama-gōri, Musashi.
Kamewaki, Sado-gōri. Sado.

XII. STEATITE, AGALMATOLITE, ASBESTOS AND GYPSUM.

Steatite and Agalmatolite.—Steatite and agalmatolite occur chiefly in regions composed of liparite, or as a secondary product of alteration of ultra-basic eruptive rocks. Agalmatolite is sometimes found interbedded in Mesozoic schalstein. The following are the localities of the minerals:

Steatite:	Machiya, Kuji-gōri, Hitachi.
	Shima, Azuma-gōri, Kōzuke.
	Mineokayama, Awa-gōri, Awa in Honshū.
	Minano, Chichibu-gōri, Musashi.
	Hiraho, Kami-Takai-gōri, Shinano.
	Haguri, Kurimoto-gōri, Ōmi.
	Taharakami, Iwanashi-gōri, Bizen.
	Kirihata, Yoshiki-gōri, Suō.
	Mie, Nishi-Sonogi-gōri, Hizen.
	Nomo, „ „
	Seki, Tamana-gōri, Higo.
	Yabe, Kami-Mashiki-gōri.
Agalmatolite:	Tatsuno, Ibo-gōri, Harima.
	Fukumoto, Kanzaki-gōri, „
	Ochi, Taka-gōri, „
	Mitsuishi, Wake-gōri, Bizen.
	Shōkōzan, Hiwa-gōri, Bingo.
	Matsubara, Yamagata-gōri, Aki.

Asbestos.—Asbestos is found as a secondary decomposition product of serpentine and pyroxenite. The mineral found in Hizen and Higo is of a good quality and is employed for technical purposes. The localities of asbestos are

Nagasaki, Minami-Uonuma-gōri, Echigo.
Ōhinata, Minami-Saku-gōri, Shinano.
Ōsa, Hiwa-gōri, Bingo.
Obira, Ōno-gōri, Bungo.

Ōgushi, Nishi-Sonogi-gōri, Hizen.
Takahama, „ „
Shimosato, Shimo-Mashiki-gōri, Higo.
Sawatari, Kami-Mashiki-gōri, „

Gypsum.—Gypsum occurs in rocks acted upon by hot springs or in mineral veins. This substance is found in the following localities:

Kami-Higashiyama, Higashi-Murayama-gōri, Uzen.
Miyazaki, Kami-gōri, Rikuzen.
Seishidō, Iwase-gōri, Iwashiro.
Momura, Nasu-gōri, Shimotsuke.
Toi, Kimizawa-gōri, Izu.
Toyooka, Koma-gōri, Kai.
Okuyamada, Takai-gōri, Shinano.
Ōkawa, Ashikita-gōri, Higo.

XIII. LIMESTONE.

Limestone is widely distributed in all geological formations and occurs in most provinces. In gneiss we find crystalline limestone, in the Palæozoic and Mesozoic formations fossiliferous limestone, and in the Tertiary more or less marly varieties. It is quarried for wall plaster, for mineral manure and for the manufacture of *shikkui* and cement.

The important lime-producing districts are as follows:

Higashi-Iwai-gōri, Rikuchū.
Tome-gōri, Rikuzen.
Motoyoshi-gōri, „
Tamura-gōri, Iwaki.
Sōma-gōri, „
Nishi-Ibaraki-gōri, Hitachi.
Taga-gōri, „
Aso-gōri, Shimotsuke.

Kita-Kanra-gōri, Kōzuke.
Tano-gōri, „
Nishi-Tama-gōri, Musashi.
Chichibu-gōri, „
Nishi-Kubiki-gōri, Echigo.
Tonami-gōri, Etchū.
Kami-Niikawa-gōri, Etchū.
Shimo-Niikawa-gōri, „
Ōno-gōri, Echizen.
Nanjō-gōri, „
Tsuruga-gōri, „
Nyu-gōri, „
Onyu-gōri, Wakasa.
Minami-Saku-gōri, Shinano.
Kami-Ina-gōri, „
Shimo-Ina-gōri, „
Suwa-gōri, „
Kita-Koma-gōri, Kai.
Haibara-gōri, Tōtōmi.
Inasa-gōri, „
Fuwa-gōri, Mino.
Ōno-gōri, „
Ibi-gōri, „
Yana-gōri, Mikawa.
Atsumi-gōri, „
Sakata-gōri, Ōmi.
Inukami-gōri, „
Inabe-gōri, Ise.
Atetsu-gōri, Bitchū.
Kawakami-gōri, „
Hiwa-gōri, Bingo.
Jinseki-gōri, „
Mine-gōri, Nagato.
Tosa-gōri, Tosa.
Higashi-Uwagōri, Iyo.
Kiku-gōri, Buzen.
Tagawa-gōri, „

Yatsushiro-gōri, Higo.
Ashikita-gōri, „

XIV. FLUORSPAR, TALC, MICA AND QUARTZ.

Fluorspar.—Fluorspar occurs in veins in acid eruptive rocks. It is used in the ceramic and glass industries. The localities of the mineral are as follows:

Omodani, Ōno-gōri, Echizen.
Hodatsusan, Hagui-gōri, Noto.
Obira, Ōno-gōri, Bungo.

Talc.—Talc occurs in decomposed serpentine and in pyroxenite in the following localities:

Torinomi, Higashi-Iwai-gōri, Rikuchū.
Akihata, Kanra-gōri, Kōzuke.
Soehi, Chiisagata-gōri, Shinano.
Kita-Kashiwagi, Minami-Saku-gōri, Shinano.
Misawa, Chichibu-gōri, Musashi.
Yorii, Hanzawa-gōri, „
Shimozato, Hiki-gōri, „
Futō, Awa-gōri, Awa in Honshū.
Kawakami, Hino-gōri, Hōki.
Gaku, Oe-gōri, Awa in Shikoku.
Arakawayama, Nii-gōri, Iyo.
Kurozeyama, „ „.

Mica.—Mica occurs chiefly in pegmatitic dykes cutting granite and gneiss, sometimes in sericite-schist. Large crystals are very rare and the pulverized mineral is used in the paper manufacture. Following are the localities of the mineral:

Machiya, Kuji-gōri, Hitachi.
Sakasaki, Nukada-gōri, Mikawa.
Yatsuomote, Hazu-gōri, „
Mikata, Mikata-gōri, Wakasa.
Okuyane, Izushi-gōri, Tajima.

Quartz.—Quartz occurs in Palæozoic quartzite, and weathered acid eruptive rocks, as well as in sand of younger formations. Its use for glass manufacture is not yet developed as it ought to be. The following are the chief localities:

Abashiri, Abashiri-gōri, Kitami.
Horinouchi, Mogami-gōri, Ugo.
Yoshima, Iwaki-gōri, Iwaki.
Sanage, Nishi-Kamo-gōri, Mikawa.
Ikai, Kuwana-gōri, Ise.
Tadosan, „ „
Setokaneyama, Nishi-Muro-gōri, Kii.
Mogi, Nishi-Sonogi-grōi, Hizen.

XV. PORCELAIN GLAZE, MINERAL PIGMENTS AND MEDICINAL MINERALS.

Porcelain-glaze.—Porcelain-glaze is commonly a mixture of quartz, feldspar, borax, soda, oxides of tin and of lead, powdered glass, etc. in variable proportions. In Japanese potteries the glazes used are very often natural products of the weathering of liparite, as the glaze of the Arita porcelain, and many others are mixtures of feldspar, lead-carbonate, wood-ash etc.

Mineral Pigments.—The mineral pigments used in Japan from remote times comprise cinnabar, malachite, azurite, red lead, realgar and orpiment, lead carbonate, iron oxides, *benigara* (a mixture of ferric oxide and clay derived from decomposition of pyrite), ultramarine, etc. The following is a list of the chief localities of such minerals:

Gosu or impure earthy cobalt:	Kasahara, Toki-gōri, Mino. Tsumagi, „ „
Malachite and Azurite:	Ashio, Shimozuke. Naganobori, Mine-gōri, Nagato.

	Tada, Kawabe-gōri, Settsu.
	Seto, Kasugai-gōri, Owari.
Benigara :	Sakamoto, Kawakami-gōri, Bitchū.
Chromite :	Hidakairi-gawa, Hidaka.
	Washidani, Ōno-gōri, Bungo.
Cinnabar :	Setamai, Kesen-gōri, Rikuchū.
	Komagaeri, Uda-gōri, Yamato.
	Suii, Naka-gōri, Awa in Shikoku.
Molybdenite :	Kadowara, Naka-Kambara-gōri, Echigo.
	Matsukawa, Chikuma-gōri, Shinano.
	Aibuchi, Ōhara-gōri, Izumo.
Realgar :	Jōzankei, Sapporo-gōri, Ishikari.
	Osorezan, Shimokita-gōri, Mutsu.
Orpiment :	„ „ „
	Onikōbe, Tamatsukuri-gōri, Rikuzen.
Fergusonite :	Naegi, Ena-gōri, Mino.

Medicinal Minerals.—The following are the localities of some of the more important medicinal minerals :

Arsenic :	Kami-Sugikawa, Naka-Kambara-gōri, Echigo.
	Ihara, Shitsuki-gōri, Bitchū.
	Kiura, Ōno-gōri, Bungo.
Iron vitriol and *Benigara :*	Sakamoto, Kawakami-gōri, Bitchū.
	Kami-Kojiro, Atetsu-gōri, „
	Eyomi, Tsudaka-gōri, Bizen.
	Kegi, Numata-gōri, Aki.
Alum :	Narugo, Tamatsukuri-gōri, Rikuzen.
	Yumoto, Nasu-gōri, Shimotsuke.
	Myōkozan, Naka-Kubiki-gōri, Echigo.
	Beppu, Hayami-gōri, Bungo.
Gypsum :	(See under the head of gypsum).
Copper vitriol :	Ashio, Aso-gōri, Shimotsuke.
	Ōitani, Kawanuma-gōri, Iwashiro.
	Osaruzawa, Kazuno-gōri, Rikuchū.
Salt :	Kashio, Shimo-Ina-gōri, Shinano.
	Ōshio, Yama-gōri, Iwashiro.
Cerussite :	Uchinokuchi, Ōno-gōri, Bungo.

	Ōtomi, Ōno-gōri, Hida.
Alabaster:	Toyooka, Koma-gōri, Kai.
	Narugo, Tamatsukuri-gōri, Rikuzen.

XVI. SULPHUR.

Sulphur occurs profusely in the volcanic regions of Japan. From the solfataras of many active as well as extinct volcanoes, sulphuretted vapour is constantly emanating, and sublimated sulphur is actually in course of deposition around the openings, from which the vapour issues as in the Aso, the Kirishima and the Hakone volcanic districts. Sulphur is also very often found as a deposit mixed up with ejected materials inside craters. By far the most interesting deposit of sulphur is that of Tsurugi-yama, north of Komaga-dake, Rikuchū, where ancient streams of sulphur interbedded in volcanic rocks are mined.

Below are the names of the principal sulphur mines with their production in *kin* in 1899:

Moyoro, Shibetoro-gōri, Etorofu-jima	155,428
Shimanobori, Chichikaribets-mura, Kunashiri-jima	1,075,000
Ichibishinai, Petoka-mura, „	57,465
Pontō, „ „	107,500
Shiretoko, Shari-gōri, Kitami	25,000
Atosanupuri, Kawakami-gōri, Kushiro	155,428
Akan, Akan-gōri, Kushiro	947,469
Iwaonupuri, Iwanai-gōri, Shiribeshi	1,624,089
Osatspe, Kayabe-gōri, Oshima	513,750
Yamamoto, Ikusagawa-mura, Kameda-gōri, Oshima	860,985
Shirikishinai, Kameda-gōri, Oshima.	787,500
Esan, „ „	185,750
Tadohokke, „ „	46,250
Usori, Shimokita-gōri, Mutsu	573,137
Ishikarido, Tazawa-mura, Senboku-gōri, Ugo	899,535
Ryōgoku, „ „ „	79,509
Sukawa, Okachi-gōri, Ugo	150,000

Tsurugiyama, Itsukushi-mura, Nishi-Iwai-gōri, Rikuchū.	2,834,096
Araodake, Tamatsukuri-gōri, Rikuzen	58,242
Onikōbe, (Arayu) „ „	921,008
Numashiri, Yama-gōri, Iwashiro	422,900
Kusatsu, Azuma-gōri, Kōzuke	316,400
Yonago, Kami-Takai-gōri, Shinano	1,297,558
Umijiri, Minami-Saku-gōri, „	85,313
Shirataki, Hachijō-jima	43,750
Yakeyama, Kusu-gōri, Bungo...	202,675
Kujūsan, Naori-gōri, „	503,125
Shiratori, Nishi-Morokata-gōri, Hyūga	217,000
Shimo-Nakatsugawa, Aira-gōri, Ōsumi	41,500
Iwōgashima, Ōsumi	88,750
Yakushima, Ōshima...	45,000

XVII. PHOSPHATES.

Phosphates occur in the Tertiary formations in Hyūga, Uzen, Ugo and other provinces. In the former the strata containing the phosphates are calcareous sandstone and shale, while in the latter the phosphates occur in marl intercalated in tufaceous sandstone and shale. According to S. Ōtsuka, there are four different modes of occurrence of phosphatic rocks in Japan: namely,

1. In nodular or lenticular masses;
2. In phosphatic beds;
3. Impregnated in fossils or casts of shells;
4. In brecciated phosphatic rocks.

Of these four categories, the first three have higher percentages in phosphatic content, which is usually in the form of apatite or vivianite. The average content of phosphoric acid is less than 10 per cent., though it may sometimes be above 20 per cent. in very rich specimens. The content of phosphorus is usually less in calcareous nodules than in clayey. The size of masses or nodules may vary from a few centimetres up to several feet in diameter. The beds form very thin layers impregnated with phosphate in shale or sandstone.

Below are the names of districts where phosphatic minerals are found:

Yamamoto-gōri, Ugo.
Mogami-gōri, Uzen.
Kani-gōri, Mino.
Miyazaki-gōri, Hyūga.
Minami-Naka-gōri, „

XVIII. MINERAL SPRINGS.

Owing to the character of its geological structure, Japan is naturally rich in mineral springs, the chief of which are as follows:

Saline:
Dai, Hienuki-gōri, Rikuchū.
Tsuruhagi, Minami-Murayama-gōri, Uzen.
Tagawa, Nishi-Tagawa-gōri, „
Narugo, Tamatsukuri-gōri, Rikuzen.
Sakunami, Miyagi-gōri, „
Yoshida, Kurokawa-gōri, „
Aone, Shibata-gōri, „
Kamasaki, Katta-gōri, Iwaki.
Tōkatta, „ „
Tsuchiyu, Shinobu-gōri, Iwashiro.
Iizaka, „ „
Shin-yu, Date-gōri, „
Iwane, Yama-gōri, „
Higashiyama, Kita-Aizu-gōri, „
Kaikake, Minami-Uonuma-gōri, Echigo.
Yumoto, Nasu-gōri, Shimotsuke.
Shiobara, Shioya-gōri, „
Ikao, Nishi-Gumma-gōri, Kōzuke.
Shima, Azuma-gōri, „

Isobe, Usui-gōri, Kōzuke.
Yabuzuka, Nitta-gōri, „
Hakone, Ashigara-Shimo-gōri, Sagami.
Yugawara, „ „
Atami, Tagata-gōri, Izu.
Izusan, „ „
Matsubara, „ „
Yugano, „ „
Shuzenji, „ „
Yugashima, „ „
Kami-Fuchū, Nishi-Yamanashi-gōri, Kai.
Antai, Shimo-Takai-gōri, Shinano.
Tsunoma, „ „
Satoyamabe, Higashi-Chikuma-gōri, Shinano.
Shimo-Suwa, Suwa-gōri, „
Yunohora, Mugi-gōri, Mino.
Yamada, Nei-gōri, Etchū.
Ogawa, Shimo-Niikawa-gōri, Etchū.
Yuwaki, Ishikawa-gōri, Kaga.
Tatsuguchi, Nomi-gōri, „
Kishigawa, Kahoku-gōri, „
Yamanaka, Enuma-gōri, „
Yamashiro, „ „
Wagura, Kashima-gōri, Noto.
Nyū, Take-gōri, Ise.
Arima, Arima-gōri, Settsu.
Yushima, Kinosaki, Tajima.
Yoshioka, Takakusa-gōri, Hōki.
Iwai, Iwami-gōri, „
Tamatsukuri, Yatsuka-gōri, Izumo.
Yunotsu, Nima-gōri, Iwami.
Yunosato, Shōnan-gōri, Mimasaka.
Yubara, Ōba-gōri, „
Yuda, Yoshiki-gōri, Suō.
Yumya, Toyora-gōri, Nagato.
Hirata, Hayami-gōri, Bungo.
Yunohira, „ „
Obama, Takaku-gōri, Hizen.

Tochinoki, Aso-gōri, Higo.
Yuyama, „ „
Hayashi, Kuma-gōri, „
Rokutanda, Ibusuku-gōri, Satsuma.
Inumuta, Kawanabe-gōri, „
Ichiki, Hioki-gōri, „
Sulphuretted: Take, Naka-Tsugaru-gōri, Mutsu.
Onikōbe, Tamatsukuri-gōri, Rikuzen.
Atsumi, Nishi-Tagawa-gōri, Uzen.
Akayu, Higashi-Oitama-gōri, „
Tochiomata, Kita-Uonuma-gōri, Echigo.
Nikkō-Yumoto, Kami-Tsuga-gōri, Shimotsuke.
Kawarayu, Azuma-gōri, Kōzuke.
Ashinoyu, Ashigara-Shimo-gōri, Sagami.
Nozawa, Shimo-Takai-gōri, Shinano.
Kami-Suwa, Suwa-gōri, „
Bessho, Chiisagata-gōri, „
Awazu, Nomi-gōri, Kaga.
Yunomine, Higashi-Muro-gōri, Kii.
Unzendake, Minami-Takaku-gōri, Hizen.
Yamaga, Kamoto-gōri, Higo.
Iwōdani, Kuwabara-gōri, Ōsumi.
Miyanoshita, Sō-gōri, „
Miyanowaki, „ „
Tobioka, Ōsumi-gōri, „
Carburetted: Sekiyama, Naka-Kubiki-gōri, Echigo.
Saimyōji, Tonami-gōri, Etchū.
Ogawa, Shimo-Niikawa-gōri, Etchū.
Matsudera, Kahoku-gōri, Kaga.
Mitate, Mie-gōri, Ise.
Seto-Kanayama, Nishi-Muro-gōri, Kii.
Oku-Hirano, Mukō-gōri, Settsu.
Suwayama, Kobe, „
Maga, Mashima-gōri, Mimasaka.
Beppu, Hayami-gōri, Bungo.
Hamawaki, „ „
Takeo, Kishima-gōri, Hizen.
Ureshino, Fujitsu-gōri, „

	Hinagu, Ashikita-gōri, Higo.
	Yunomoto, Nishi-Moroka-gōri, Hyūga.
	Yunoura, Hioki-gōri, Satsuma.
	Iriki, Satsuma-gōri, „
	Sukubota, Aira-gōri, Ōsumi.
	Kinofusa, Sō-gōri, „
Acid:	Sukawa, Minami-Murayama-gōri, Uzen.
	Hashimoto, Date-gōri, Iwashiro.
	Niwasaka, Adachi-gōri, „
	Fukahori, Adachi-gōri, Iwashiro.
	Kusatsu, Azuma-gōri, Kōzuke.
	Shibu, Shimo-Takai-gōri, Shinano.
	Kannawa, Hayami-gōri, Bungo.
	Nagase, Kawanabe-gōri, Satsuma.
Simple:	Matsunoki, Higashi-Tsugaru-gōri, Mutsu.
	Takase, Iwafune-gōri, Echigo.
	Yata, Kita-Kambara-gōri, „
	Yuzawa, Minami-Uonuma-gōri, Echigo.
	Ōyu, Kita-Uonuma-gōri, „
	Ōsuge, Kuji-gōri, Hitachi.
	Fukurota, „ „
	Yumoto, Ashigara-Shimo-gōri, Sagami.
	Sokokura, „ „
	Iwashita, Higashi-Yamanashi-gōri, Kai.
	Kami-Asama, Higashi-Chikuma-gōri, Shinano.
	Shimo-Asama, „ „
	Bessho, Chiisagata-gōri, Shinano.
	Shimomyō, Nei-gōri, Etchū.
	Komono, Mie-gōri, Ise.
	Kami-Arifuku, Naka-gōri, Iwami.
	Yumoto, Ōtsu-gōri, Nagato.
	Yumachi, „ „
	Jishōji, Asa-gōri, „
	Dōgo, Unzen-gōri, Iyo.
	Musashi, Tsukushi-gōri, Chikuzen.
	Fujita, Yume-gōri, Chikugo.
	Kuzuo, Mii-gōri, „
	Furuyu, Ogi-gōri, Hizen.

Ichihino, Satsuma-gōri, Satsuma.
Yukawachi; Izumi, „
Shikine, Sō-gōri, Ōsumi.

(THE END.)

GLOSSARY OF JAPANESE WORDS FOUND ON THE MAP AND IN THE TEXT.

Bana	See *Hana*.
Bets or *Pets* (in Hokkaidō)	River.
Bi or *Hi*	Mineral vein.
Dake	See *Take*.
Dani	See *Tani*.
Dao	See *Tao*.
Gata	See *Kata*.
Gawa	See *Kawa*.
Goe	See *Koe*.
Gōri	See *Kōri*.
Guntō	Group of islands.
Hana or *Bana*	Cape or Promontory.
Hi	See *Bi*.
Higashi	East.
Ike	Pond or Lake.
Jima	See *Shima*.
Kai	Sea.
Kaikyō	Strait.
Kaku (in Taiwan)	Cape or Promontory.
Kami	Upper.
Kata or *Gata*	Lagoon.
Kawa or *Gawa*	River.
Kei (in Taiwan)	River.
Kin	Measure of weight. 1 =560 grams.
Ko	Lake.
Koe or *Goe*	Mountain-pass.
Koku	Measure of capacity. 1 *koku*=180.39 ltr.
Kōri or *Gōri*	District.
Kwamme	Measure of weight. 1 *kwan*=3.75 kilog.
Minami	South.
Mine	Mountain or Peak.
Misaki	Cape or Promontory.
Momme	Measure of weight. 1 *momme*=3.75 grams.
Mura	Village.
Nada	Sea.
Naka	Middle.
Nishi	West.
Nobori or *Nupuri* (in Hokkaidō)	Mountain.
Numa	Pond.
Nupuri	See *Nobori*.
Pets	See *Bets*.
Rettō	Group of islands.
Saki or *Zaki*	Cape or Promontory.
San or *Zan*	Mountain.
Shima or *Jima*	Island.
Shimo	Lower.
Sho (in Taiwan)	Island.
Shotō	Islands.
Take or *Dake*	Mountain.
Tani or *Dani*	Valley.
Tao or *Dao*	Mountain-pass.
Tō	Island.
Tōge	Mountain-pass.
Umi	Sea.
Ura	Sound.
Wan	Bay or Gulf.
Yama	Mountain.
Zaki	See *Saki*.
Zan	See *San*.

明治三十五年八月二十日印刷
明治三十五年八月二十五日發行

著作權所有　農商務省地質調査所

印刷所　（株式會社）東京築地活版製造所
東京市京橋區築地二丁目十七番地

印刷者　野村宗十郎
東京市京橋區築地三丁目十五番地

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